THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XVIII.—*On some results of the Earth's Contraction from cooling;* by JAMES D. DANA. Part V, *Formation of the Continental plateaus and Oceanic depressions.*

V. FORMATION OF THE CONTINENTAL PLATEAUS AND OCEANIC DEPRESSIONS.

IN my papers of 1846 and 1847, I attributed the formation of the great plateaus, called continents, and of the oceanic depressions, to unequal contraction, observing that the oceanic crust, by being the later in consolidation, became more depressed through the continued contraction than the already firm or less-contracting continental crust. The steps in the process I propose now to consider, as a means of further elucidating the subject.

1. *Unequal contraction a fact.*

The *fact* of unequal contraction is manifest from the inequality of level that exists over the sphere dividing it into oceanic depressions and continental plateaus; and unequal contraction, the material of the crust being essentially the same over the two kinds of regions, implies an unequal rate of cooling. Moreover, it is a necessary conclusion that the great areas first consolidating should have been first free from that chemical activity, and those ebullition-like movements due to escaping vapors, which are inseparable from the fluid condition of rocks under merely atmospheric pressure.

2. *Location of the continental areas.*

The areas first to become quiet, and first to cool and consolidate, would have been the shallowest areas, that is, those be-

neath which the solid nucleus of the globe reached nearest to the surface; for this approach to the surface would have been favored by the chemical quiet; and the less depth would have insured more rapid cooling.

The solid state of the interior mass, under the Hopkins' theory, is due to the pressure of the outer portion, this pressure being capable of producing an increase of density, and, at some depth, that density which belongs to the solid rock; so that downward, either from the plane at this depth, or from some level or levels below it, actual solidity would have existed. It may be that when exterior solidification, that is, the solidification of the crust, was about to begin, the outer limit of the interior solid mass over the solidifying areas was quite up to the spherical plane in which the rock of the interior had the density of solidity. It is at least certain that its limit was as near the surface as was possible under the temperature then existing.

3. *Nature of the cooling crust, and of the liquid layer of which it was formed.*

The change of specific gravity or density which the rock-material underwent in passing from the liquid to the solid state is part of the data required for conclusions on the subject in view; and with reference to it we may first consider the nature of the rock-material.

The larger part of the igneous rocks of the globe are ejections, according to the evidence which has been presented, either from regions *within* the true crust of the earth—that is, the part situated below the supercrust and which was a direct result of the cooling—or from the plastic layer or seas underneath. In either case they are testimony, and have long been so regarded, with respect to the outer liquid layer of the melted sphere. The next best testimony we have is that from the earlier of the surface formations—the Archæan (Azoic). Another source of conclusions, appealed to effectually by Daubrée,* is the constitution of meteorites and parallel facts in the earth's igneous and metamorphic rocks. Still another, used by Hunt, is reasoning from physical and chemical laws to the probable results under the supposed conditions of a cooling globe. We thus arrive at the following conclusions.

(*a.*) The *more prominent minerals* were the following. (1) Some iron-bearing species (bearing also magnesia and lime) of the amphibole family, as *augite, hornblende;* (2) the iron-and-magnesia mineral *chrysolite* (or olivine), to which Daubrée, on the evidence just referred to, gives great prominence; (3) species of

* Expériences synthétiques relatives aux Météorites. Rapprochements auxquels elles conduisent, tant pour la formation de ces corps planétaires que pour celle du globe terrestre; par M. Daubrée. Comptes Rendus, lxii, 1866.

feldspar, either the lime feldspar called *anorthite*, the lime-and-soda kind called *labradorite*, the soda-and-lime kind *oligoclase* (and andesine), the soda-feldspar (containing usually some potash) *albite*, the potash-feldspar (containing usually some soda) *orthoclase;* of which feldspars the first two are lowest in silica, 45–55 p. c., the third intermediate in amount of silica, or 60 to 64 p. c., the last two the highest, 65 to 70 p. c.; (4) *magnetite* (or magnetic iron ore Fe_3O_4, but often titaniferous); and (5) perhaps *quartz* or free silica, and *mica*. Serpentine and chlorite are omitted from the list on the ground that they are always metamorphic. The question with regard to quartz is discussed below.

(*b.*) The *principal rocks* in their relation to the subject before us fall naturally, as Elie de Beaumont first formally announced,* into two series—although there are intermediate kinds through which the two graduate into one another:—*one*, low in silica, or *basic*, containing less than 56 p. c. of silica; *the other*, high in silica or *acidic*, containing 56 p. c. or more.

The *basic* rocks include dolerite and the related igneous rocks: made up of augite and labradorite, with sometimes anorthite or oligoclase, often chrysolite, and generally magnetite in disseminated grains, and varying in specific gravity mostly between 2·8 and 3·2.

The *acidic* comprise (1) most trachyte and related feldspathic rocks, consisting of one or more of the feldspars, oligoclase, albite, or orthoclase, with usually a little hornblende and magnetite, and sometimes mica, and not unfrequently free quartz—sp. gr.=2·5–2·75; (2) syenite, consisting of orthoclase and hornblende with quartz—sp. gr.=2·9–3·1; hyposyenite, consisting of orthoclase and hornblende without quartz—sp. gr.=2·9–3·2;† diorite, consisting chiefly of oligoclase or albite with hornblende—sp. gr.=2·80–3·1; granite, consisting of orthoclase (sometimes along with albite or oligoclase), quartz and mica—sp. gr.=2·6–2·75.

(*c.*) These igneous rocks are also conveniently arranged with reference to their origin into an *iron-bearing* and a comparatively *iron-free* series.

* Bull. Soc. Geol. de France, II, iv, 1253, 1847. De la Beche has the idea in chapter xviii, on igneous rocks, of his Geological Researches (1834). Bunsen uses it in his memoir on the volcanic rocks of Iceland (Pogg., lxxxiii, 201, 1851), and also Durocher later, in his memoir on Comparative Petrology.

† The name *syenite* belongs by right of priority to the quartz-bearing rock, as it was described from the locality Syene in Egypt, where that kind occurs; and I, therefore, call the kind free from quartz *hyposyenite*. Syenite is a rock of the hornblendic series in all its geological relations, it graduating often into hyposyenite in Archæan regions; and it is bad to make it, as done by some German lithologists, a hornblendic variety of granite. It deserves to stand as a distinct species, and it naturally leads off the hornblendic or syenitic series of crystalline rocks, as granite does the non-hornblendic or granitic series.

The *former* include the rocks containing as essential constituents one or more of the iron-bearing minerals, augite, hornblende and chrysolite, and often also magnetite; and are divided into two groups, the *doleritic*, containing pyroxene, and the *syenitic* containing hornblende in place of pyroxene.

The *latter* comprise those mostly (seldom wholly) free from these iron-bearing minerals, as the *trachytic* and *granitic* kinds.

(*d.*) The *presence of quartz* among the chief constituent minerals of the true crust is not certain. Of the above-mentioned rocks, the basic iron-bearing (or doleritic) kinds are far the most abundant among acknowledged igneous rocks; and this fact seems to indicate that *quartz or free silica was not abundant in the original liquid rock of the globe.* Its *absence*, which Mr. Hunt urges, is seemingly opposed by the fact that it is present in so many trachytes, as well as in syenite and granite, and the related rocks. But Hunt is right in holding that in general granite and syenite (the quartz-bearing syenite) are undoubtedly metamorphic rocks where not vein-formations, as I know from the study of many examples of them in New England; and the veins are results of infiltration through heated moisture from the rocks adjoining some part of the opened fissures they fill. These rocks, although common, present therefore no positive testimony on the side of the presence of quartz. Mr. Hunt urges, in support of his opinion, the experiment of Rose, in which fused quartz on cooling had the low density and other characters of the form of silica called opal, and not those of quartz. But the evidence is inconclusive, since a laboratory experiment cannot inform us what would be the condition of silica on cooling from fusion, provided the process of solidification took some millions of years. But Rose's experiment does seem to settle the question as regards all quartz-veins, since if of igneous origin, their little width would have insured comparatively rapid cooling; and it thus sustains the evidence in favor of the view that such veins, like most mineral veins, were filled through the aid of heated moisture. Professor Hunt's argument from the probable condition of the material of the liquid sphere, when about to solidify at surface,—or the fact that the lime and magnesia now in our limestones and waters, and the soda in our waters, must have been mainly in the condition of silicates, and that therefore the free silica would have thus been in combination,—is of great weight; and, considering the vast amount of limestone in the earth's formations, it favors the view, derived from the prevailing doleritic character of igneous rocks, that silica would have been mostly, if not wholly, in combination, and that the chief feldspars present were the lime-and-soda species, labradorite and oligoclase. Granite and syenite—common rocks of Archæan terranes—

are just the rocks that are likely to have been formed over the earth's surface after the action on the crust of the foul atmospheric vapors that settled upon it as it began to solidify. If there were mainly doleritic material and other labradorite mixtures in that crust, the result of the conflict would have been a removal of part of the bases and the liberation of silica, making free quartz and quartz-bearing rocks.

Again, the general fact that the doleritic rocks, and even most trachytic, contain disseminated grains of *uncombined* oxide of iron in the form of magnetite (Fe_3O_4) adds to the strength of the argument against the general diffusion of quartz, that is, free or uncombined silica, if not proving its absence.

(*e.*) The *presence of a large proportion of iron* is a marked feature of most igneous rocks. This ferriferous quality is not characteristic solely of the doleritic and syenitic kinds; even the most purely feldspathic trachytes usually contain some disseminated magnetite and hornblende; and from this extreme there is a shading off in trachytic rocks toward dolerites, syenites, or hyposyenites. It should be here understood that augite and hornblende are essentially identical in chemical constitution, though differing in crystallization. Hornblende has often a slight excess of silica (making the oxygen ratio of the bases and silica frequently $1:2\frac{1}{4}$ as in the feldspar oligoclase, instead of $1:2$, as in augite, and this may be one reason for its occurrence by preference in the trachytes, in which oligoclase and orthoclase predominate, and that of augite in the dolerites, in which labradorite is the predominant feldspar. In labradorite this ratio is $1:1\frac{1}{2}$, and in andesine $1:2$. Mixtures of labradorite and oligoclase, which constitute the base of some doleritic rocks (melaphyres, in which the silica constitutes over 55 per cent), would have $1:2$ for this oxygen ratio when the proportion of labradorite to oligoclase was 1 to 2.

The basic iron-bearing feature of the first solidified crust is attested to also by the nature of the lowest rocks of the supercrust, that is, by the Archæan formations overlying the true crust and directly or indirectly made from it. We find among the Archæan terranes the feldspar labradorite far more abundant than in any later metamorphic rocks; the rock hypersthenite common, which is much like dolerite in elemental constitution; others, ossipyte and a chrysolitic hypersthenite, which are closely related to peridotite or chrysolitic dolerite; other rocks that are almost solely chrysolite; another, diabase, which has the composition of a chloritic dolerite; other kinds, referred to hypersthenite and diabase, which approach melaphyre. And besides, there are diorite, consisting of hornblende and albite or oligoclase, and hyposyenite, consisting of hornblende and orthoclase.

These iron-bearing kinds of Archæan metamorphic rocks much exceed in amount the granitic kinds that are free from iron. Moreover, in these Archæan formations, the granitic as well as the iron-bearing, there are immense beds of iron-ore, as seen in New York, Canada, Northern Michigan, Missouri, Sweden and Norway, the thickness of single beds frequently exceeding a hundred feet; and thus, although the surface over which Archæan rocks are exposed is relatively small, its iron is in vast amount. In fact, unlike human history, the earth's iron age was its earliest. Now since these great iron-ore beds are of sedimentary or marsh accumulation (for they occur interstratified with quartzite, chlorite schist, syenitic schist, and other metamorphic rocks), the iron was gathered from the pre-existing crust rocks. They therefore prove that iron was a very common ingredient in the original fused material of the surface of the liquid globe.

(*f.*) We hence have reason for the inference that the original fused material contained largely the ingredients of the iron-bearing rocks, dolerite, peridotite, diorite, hyposyenite, besides trachyte and the related kinds; and *perhaps* in small proportions those of the quartziferous trachytes, if not of granite and syenite.

It is not certain, from present knowledge, whether the slow cooling would not have made hornblende through the crust-mass, in place of the akin species augite. Yet the considerations mentioned on the preceding page suggest that augite may have characterized the basic portions of the crust, and hornblende the smaller acidic portions; and if so the prevailing rock is strictly doleritic.

(*g.*) In view of the large proportion of iron, the *mean specific gravity of the true crust* can hardly be less than 2·9, and probably it is as high as 3·0.

(*h.*) The *method of distribution* of the basic (doleritic) and the less abundant acidic (or trachytic) kinds in the earth's outer viscid layer before solidification—whether in separate layers, the latter over the former, as Durocher urges, or whether in separate local streams or regions made by the boiling movements and the great oceanic-like currents in the liquid mass, through the principle of liquation on a large scale—need not be here considered. I merely add that observed facts seem to be best explained on the latter view, since the existence of the two layers is not proved by the study of the Archæan terranes. If it had existed at the beginning of solidification, and the trachytic layer was thick enough not to have been obliterated by cooling before the era of the more recent trachytic ejections over the great Pacific slope, the constituents of the iron-bearing or doleritic rocks should exist but sparingly in the Archæan, instead of being the prevailing kinds.

4. *Change of density and volume in solidification.*

All the rocks above mentioned have a higher density in the solid state than when in fusion. According to Delesse,* granite decreases in density in passing from the stone to the glass condition,† 9 to 11 per cent; syenite, syenitic granite 8 to 9; diorite, 6 to 8; dolerite and melaphyre, 5 to 7; basalt and trachyte 3 to 5 per cent. The difference in volume is thus large between a rock in the solid and glass state. As to the difference between the glass and liquid states we have no precise observations, and only know that it is very small.‡

From the above facts, sustaining the near absence of quartz-bearing rocks from the crust, and, therefore, of granite or syenite, and the other considerations presented, we may take 8 per cent as the probable average change of density for the earth's crust between the stony and the liquid states; which is equivalent to a change of volume from 100 to 92 per cent in passing from the liquid to the stone condition.

5. *Process of solidification and continent-making.*

The crust over the areas of solidification, after attaining a thickness that would enable it to overcome by its gravity the cohesion in the liquid rock beneath, would have sunk in masses, and then have been remelted by the heat beneath, and this remelting would have cooled somewhat the liquid layer. So, this process of crusting, and sinking with an overflow from either side, remelting, and cooling, would have gone forward until the masses could sink without much remelting, to bring up at the level where the density of the liquid layer was that of the solid rock, if this liquid layer had not become so stiffly viscid by the cooling as to offer too great resistance to their reaching quite to this level. The sinking rock-masses may have had their density somewhat increased by the pressure to which they were subjected on descending; but whatever density they acquired, this density would determine the limit to which—setting aside resistance from viscidity—they would sink. It may be that portions went down until they came in contact with the nucleal solid mass. As the crust sank the liquid material adjoining would have continued to flow over the solidifying area and add to the solidifying material.

* Bull. Soc. Geol. de France, II, iv, 1380, 1847. Delesse's results agree nearly with those of St. Claire Deville. Bischof in 1841 found the volume of basalt in the vitreous and crystalline states as 1 to 0·9298; for the same, in the fluid and crystalline states, as 1 to 0·8960; and for granite, the corresponding ratios, 1 to 0·8420, and 1·07481.

† It is to be here noted that the glass and stone conditions are distinct molecular states of the same substance, the former produced under rapid cooling, the latter under slow; and that common glass will become stone if solidified under a prolonged cooling process.

‡ I am informed that at the Lenox Glass Furnace in Berkshire, Mass., no contraction is noticed in the cooling of the glass.

Finally, a layer of crust-rock, miles in thickness, would have been made over the great continental areas. Throughout the other portions of the sphere, the surface, whether all liquid or in incipient solidification, would have the level of that of the continental areas. For the sake of the illustration, suppose them to have been all liquid, and the continental crust twelve miles thick, and the oceanic areas to go through the same process of solidification as had been completed over the continental areas: when, finally, the material of the oceanic regions had solidified down to the same plane with that of the continental, that is to the *twelve*-mile limit, the oceanic crust thus formed would have become depressed in the consolidation (on the above ratio of 8 per cent less volume for the liquid than solid) 5,000 feet; or, if the layer consolidated were thirty-six miles thick, 15,000 feet; that is, supposing the continental part to undergo no contraction during the time. As such contraction would have been in progress from the continued cooling, the above 5,000 feet is not the actual depth the basin would under the supposed circumstances have acquired; and yet, since the change of volume in the cooling of solid rock is small, it is not very wide from the fact.

The case here supposed is partly hypothetical because the condition over the oceanic areas when the solidified crust of the continental areas was completed may have been that of incipient solidification, so that some of the contraction had already taken place. But apart from this it represents correctly, as appears to me, the steps in the process, and illustrates how it is that great depressed areas would have been an inevitable result, and why they should have had comparatively abrupt sides or a basin-like character. The present mean depth of the oceanic areas below the mean level of the continental plateaus is probably about 16,000 feet. The thickness of the layer of liquid rock required to make a depression of 16,000 feet by its consolidation would be about 38¼ miles. But as contraction has gone on through time over both continental and oceanic areas, this is the mean excess of depression for the oceanic area. What part of this excess existed when the oceanic depression was first made there are no facts for satisfactorily deciding. If the coral-island subsidence was due in any considerable part to radial contraction beneath the Central Pacific crust itself, it is probable that the excess has increased even in Cænozoic time.

I find no explanation, in the present state of science, wherefore most of the dry land of the globe should have been located about the north pole, and of the water about the south. Physicists say that it indicates greater attraction, and therefore a greater density, in the solid material beneath the southern ocean. But why the mineral ingredients should have been so

gathered about the south pole as to give the crust there greater density is the unanswered query. It may be that magnetite is much more abundantly diffused through the Antarctic crust than the Arctic. This is only one of many possibilities, and it is at present without a satisfactory fact to stand upon, beyond the general truth that iron was universally present.

6. *Resulting crystalline texture of the crust.*

The doleritic and trachytic rocks of the true crust, and whatever else exists in its constitution, cannot be present with just the *texture* we find in the rocks of existing dikes and volcanic mountains. For, as above-stated, the crust has cooled with inconceivable slowness, far more extreme than that which has attended the formation of any of the coarsest granites and syenites. And, since the coarseness of crystallizations is generally in proportion to slowness of cooling, the texture of the whole should have been after the character of the coarse Archæan syenite or hyposyenite and vein granite, or else in much larger crystallizations. One or another of the cleavable feldspars is, in all probability, everywhere present; and since the cooling, and therefore the crystallization, has been in progress through many millions of years, and still goes on—the probability is that the feldspar crystallizations and cleavage-planes of the first-formed crust-layer were lengthened downward for very long distances, if not indefinitely. If so, the existence of a cleavage structure in the crust as courses of easiest fracture, such as I have appealed to elsewhere in explaining the origin of the courses in the earth's great feature-lines,* is not an unreasonable supposition.

7. *The Continents always the continental areas.*

The above-stated effects of contraction lead to the necessary conclusion that the oceanic and continental areas were defined when the earth's crust first began to form, if not also still earlier, during the progress of its nucleal solidification. It is hardly possible to conceive of any conditions of the contracting forces that should have allowed of the continents and oceans in after time changing places, or of oceans as deep nearly as existing oceans being made where are now the continental areas;—although it is a necessary incident to the system of things that the continental plateaus should have varied greatly in their outlines and outer limits, and perhaps thousands of feet in the depth of some portions of the overlying seas; and also that the oceans should have varied in the extent of their lands. The many characteristics of the continental borders: for example, the contrast between the landward and seaward slopes of the mountains, and even of the plications constituting them, the

* This Journal, II, iii, 381, 1847.

positions of volcanoes and of regions of igneous eruptions and metamorphism, indeed all the features declare which side of each border chain is the oceanic, and which the continental, and protest against speculations that would reverse the order. The early defining, even in Archæan time, of the final features of North America, and the conformity to one system visibly marked out in every event through the whole history—in the positions of its outlines and the formations of its rocks, in the character of its oscillations and the courses of the mountains from time to time raised, sustain the statement that the American continent is a regular growth. The same facts also make it evident that the oceanic areas between which the continent lies have been chief among the regions of the earth's crust that have used the pent-up force in the contracting sphere to carry forward the continental developments.

If this was true of the North American continent, the same in principle was law for all continents.

CONCLUSION.

I here close this reconsideration of the views brought out in my papers of 1847. Of the principles then presented, and briefly recapitulated in the opening pages of this memoir, vol. v, pp. 423–426, I have found reason to modify some points connected with section 4 on mountain-making, and part of section 8, or that on metamorphism: the former, in consequence of some new considerations of my own, and of two ideas, of fundamental value, which I owe to LeConte;* the other in view of Mallet's recent contribution to Vulcanology. I purposely avoided in my early papers any expression of opinion as to the nature of the earth's interior (having had Hopkins's argument of 1839–1842 in view) and hence there is nothing on this point in the statements then made that requires change.†

The views on mountain-making now sustained suppose the existence, through a large part of geological time, of a thin crust, and of liquid rock beneath that crust so as to make its oscillation possible, and refers the chief oscillations, whether of elevation or of subsidence, to lateral pressure from the contraction of that crust; and this accords with my former view, and with that earlier presented by the clear-sighted French geologist, Prévost.

I hold also, as before, that the prevailing position of mountains on the *borders* of the continents, with the like location of

* Introduced in Part I, v, 431, and Part II, vi, 12, 13.

† The later paper of Prof. Hopkins, read before the British Association, did not appear in this country until after my articles of 1847 were in print; and I have since then been deferring my adoption of the views now accepted from it, until the idea of the earth's interior solidity should have additional affirmation from the physical and mathematical side. This it has recently had through the writings of Sir William Thomson and others.

volcanoes and of the greater earthquakes, is due to the fact that the oceanic areas were much the largest, and were the areas of greatest subsidence under the continued general contraction of the globe.

Beyond these points there are additions and modifications. In addition to admitting the nucleal solidity of the globe, and the present partial union of the crust to the nucleus, these include the recognition of the following principles:

(1.) That in mountain-making on the continental borders, the oceanic crust had the avantage through its lower position of *leverage*, or, more strictly speaking, of obliquely upward thrust, against the borders of the continents.

(2.) That, among mountain elevations, there are those which, like the Alleghanies, are the result of one process of making, or *monogenetic*, and those that are a final result of two or more processes at different epochs, or are *polygenetic*.

(3.) That there are two kinds of monogenetic ranges—those that are geanticlinals, or *anticlinoria*, like the region of the Cincinnati uplift; and those that were the result of a slowly progressing geosynclinal, with consequently a very thick accumulation in the trough of sedimentary beds, ending in an epoch of displacements and solidification, and often of metamorphism of the sedimentary beds, as in the case of the Alleghanies and other *synclinoria*.

(4.) That great mountain chains are combinations of synclinoria and of anticlinorian elevations.

(5.) The principle advocated by LeConte (restricted as indicated) that plication, shoving along fractures, and crushing are the true sources of the elevation that takes place *during the making* of the second of the two kinds just mentioned of monogenetic mountain ranges or synclinoria.

(6.) That, on the oceanic side of the progressing geosynclinal referred to, there has been generally, as the first effect of the thrust against the continental border, a progressing geanticlinal which usually disappeared in the later history of the region, —gravity, and the yielding and plication in the region of the geosynclinal favoring this disappearance.

(7.) That the locus of the region of subsidence on a continental border was in general alongside of a region of thickly stiffened unyielding continental crust, and that pressure against the stable area beyond was one source of the catastrophe of mountain-making.

(8.) That each epoch of plication and mountain-making ended in annexing the region upturned, thickened and solidified, to the stiffer part of the continental crust, and that consequently the geosynclinal that was afterward in progress occupied a parallel region more or less outside of the former, either landward or seaward, and commonly the latter.

(9.) The principle adopted from LeConte, that the bottom of a geosynclinal becomes weakened, as subsidence and surface sedimentary accumulations go forward, through the access of heat from below or the rise of the isogeotherms (the change of level in a given isothermal plane having been seven miles in the Appalachian region), and that this in an important degree has made possible the catastrophe in which synclinoria have resulted.

(10.) That, while igneous eruptions and metamorphism have each attended the formation of synclinoria, still in cases where the plication was greatest the igneous eruptions have been least in amount or absent; and that the most extensive igneous eruptions have taken place on continental borders after the crust had become too much stiffened to bend freely before the lateral pressure.

(11.) That in the upturning and plication attending mountain-making, the heat from the transformation of the motion was sufficient (in connection with other heat from a rise of the isogeotherms due to previous surface accumulations) to cause metamorphism; and also the pasty fusion which obliterates all stratification and gives origin to granite, and which may fill cavities or fissures, and so make veins that have all the aspect of true igneous ejections; and, as a more extreme effect, it may produce, as Mallet says, the degree of fusion which belongs to plastic trachyte, and give rise to trachytic and other ejections through fissures or volcanic vents. But—

(12.) That the chief source of igneous rock is the plastic layer situated beneath the true crust, or the local fire-seas derived from that layer.

The discussion has enlarged beyond its limits in my previous publications, and many additional facts and conclusions have been brought forward. The various conclusions go forth to be tested by the further developments of science.

ART. XIX.—*On a Secondary Spectrum of very large size, with a Construction for Secondary Spectra;* by Prof. O. N. ROOD.

WHEN two prisms of different substances are arranged so as to compensate each other for color, it is ordinarily found, on passing a ray of white light through the combination, that a residual spectrum of very small dimensions and peculiar appearance still remains. It is well known that this *secondary spectrum* is due to the circumstance, that the spacing of the colors in the two original spectra is not accurately correspondent, and

that its dimensions vary with the amount of the disproportionality of the original constituents. Sir David Brewster seems to have made the most extended set of experiments on this subject, and has given a list of substances, arranged in the order in which their spectra differ in this respect.*

His mode of experimenting was quite simple, consisting merely in giving the two prisms such refracting angles as produced the best approximation to achromatism, and then in viewing through the combination the bar of a window with the naked eye. Under these circumstances he found the window-bar fringed on one side with a very narrow line of green color, the line of color on the opposite side being purple. The secondary spectrum can also sometimes be observed as a defect in telescopic or microscopic lenses; here also we have the green and purple fringes, but as in the other case, the phenomenon is quite inconspicuous, and is easily overlooked by those to whom it is for the first time presented.

I have recently found it possible, by a proceeding of a different kind, to produce secondary spectra whose size is quite gigantic as compared with those just mentioned, and which display the fixed lines with a distinctness that allows the study of their peculiar construction by ordinary spectroscopic methods. The essential condition for the production of a large secondary spectrum is a large difference in the *spacing* of the colors of the two primary constituents, and the largest secondary spectrum observed by Brewster was that furnished by a prism of sulphuric acid in combination with one of oil of cassia, these substances standing at the opposite extremes of his table. A vastly greater difference is, however, obtained, if we employ as one of the constituents the spectrum furnished by oil of cassia, bisulphide of carbon, or even flint glass, the other being the *normal spectrum* obtained by the use of a diffraction grating. Here we approach very nearly, if we do not actually realize, the maximum difference of spacing that is attainable in the present state of optical science, and hence give to the secondary spectrum its maximum dimensions.

Apparatus, &c.—A spectroscope provided with collimating and observing telescopes was employed; it was provided with a flat circular brass plate seven inches in diameter, which supported the prism and the grating; the vertical axis around which the observing telescope revolved was capable of being adjusted under any desired portion of this plate. The observing telescope was provided with a micrometer eye-piece of the kind described by me in the July number of this Journal;

* Sir David Brewster's Treatise on New Philosophical Instruments, p. 354: see also his work on Optics.

with its aid the distances between the lines in the original, or in the secondary spectra, were measured. The collimating telescope was arranged so that its optical axis could be directed across any desired portion of the supporting brass plate. All these parts were capable of being independently leveled.

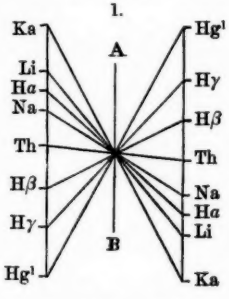
In the experiments described in this paper only two prisms were used, their angles being approximately 60°; one was made of ordinary flint glass, the other was filled with bisulphide of carbon. Mr. Rutherfurd kindly supplied me with two of his superb diffraction gratings; both were ruled on glass, the finer, No. 1, having 6480 lines to the inch, while the other, No. 2, in the same space contained 4320. The *equality* of the intervals between the lines was equal, if not superior, to that in the gratings of Nobert which have come under my observation; the spectra were brilliant.

The lines of the solar spectrum are not adapted for the study of the arrangement of the colors of the secondary spectrum, owing to its peculiar structure, consisting as it does of a spectrum bent back or folded on itself and in some portions very much contracted; the identification of solar lines becomes, hence, all but impossible in the majority of cases. Accordingly I selected a number of chemical lines of easy identification, which in point of fact proved to answer quite well. They were as follows: the potassium line at the extreme red end of the spectrum (Ka), the red lithium line (Li), the red hydrogen line ($H\alpha$), the sodium line (Na), the thalium line (Th), the blue hydrogen line ($H\beta$), and in some cases the violet hydrogen line ($H\gamma$). For the most refrangible portion of the spectrum I employed two mercury lines, viz: the final line, which is somewhat less refrangible than the solar line H, and which is marked by Huggins with the number 5158; also the line next but one to it, 4775, Huggins. This last line is a little less refrangible than the violet hydrogen line ($H\gamma$), and is far more brilliant. These lines I have indicated in the spectra given below by the symbols Hg^1 and Hg^3. The most refrangible of the caesium and rubidium lines were also sometimes employed to divide up, for purposes of measurement, the rather extensive tracts in the blue and violet portions. The potassium line was best obtained by a flame of common illuminating gas somewhat under-fed with oxygen, so as to avoid danger of fusing the platinum wire; the salt selected was the nitrate. The hydrogen lines were from a spectral tube containing the rarefied gas, the thalium line from a mixture of the sulphate of thalium with carbonate of soda, which ensured the necessary presence of the line due to the latter. The mercury lines were generated by the aid of platinum and mercury electrodes, in connexion with an induction coil and Leyden jar. All these lines were plainly visible in both the

primary spectra; in the secondary spectra, also, sometimes all were present, though usually the potassium line was too faint to admit of accurate measurement, and sometimes this was the case with the violet hydrogen line.

Mode of experimenting.—Light from the slit was rendered parallel by the collimator and fell upon *the prism*, which was placed in the position of minimum deviation for the Na line; emerging from this, it fell upon the grating, which was also arranged at its position of minimum of deviation for the same line. The vertical axis of the observing telescope was placed directly under the grating, prism and grating being arranged in the sense of balancing each other's action. With the aid of the chemical lines above enumerated and the micrometer eye-piece, a map of the secondary spectrum was then noted down, and afterward by two distinct processes, maps of the two primary spectra were obtained, the prism and the grating, as before, being in the position of minimum deviation for the Na line.

Construction for secondary spectra.—Before giving the results of these experiments, I will describe a simple construction which is quite useful in the study of secondary spectra, as it furnishes correctly, not only the order and direction in which the lines are disposed, but also their actual distances apart. If we adopt the convention of representing achromatism, not by the parallelism of lines representing the rays, but by their *intersection*, we obtain immediately the annexed construction, for the resultant action of two opposed but equal and similar spectra. Let the vertical parallel lines represent the spacing of the original spectra; joining the corresponding points by straight lines, the resultant spectrum is found on the line AB, midway between the two primary spectra, and is in this particular case a point, all the rays having been united and perfect achromatism attained, fig. 1. If, on the other hand, we reduce one of the original spectra to a point, and as before complete the construction, a real resultant spectrum will be found on the line AB, correct in its spacing and of half the size of the actual physical resultant spectrum (which in this case is the remaining original spectrum), and so on for all other cases; or in general, if S= the length of the physical resultant or secondary spectrum, or the length of any portion of it, and S' = the corresponding length of the same spectrum as constructed, then S = 2S'; or if drawn to scale, the resultant or secondary spectrum in the construction



will always be half the size of the actual physical spectrum which it represents. It is evident that the construction is independent of the relative position of the lines representing the two primary spectra, demanding only that they should be represented by straight parallel lines.

It is not actually necessary to go through the labor of executing the projections on paper, as a far more accurate result can otherwise be obtained. Upon inspecting the construction, fig. 1, or one with dissimilar primary spectra, it at once becomes evident that the distance of any two lines apart in the secondary spectrum (on the line AB), will be equal to one-half the difference between the corresponding distances in the primary constituents, or

$$l'' = \frac{l' - l}{2},$$

and hence in the actual or physical secondary spectrum we shall have

$$l'' = l' - l,$$

where l'' is the distance between any two lines in the secondary spectrum, l' and l the corresponding distances in the two primary spectra. Hence to construct a correct map of the secondary spectrum in any case, it is only necessary to make maps of the primary spectra with the spectroscope and any convenient set of lines, when the above formula at once furnishes the desired result, and gives also the point of *inflexion*, if attention is paid to the algebraic signs of the intervals between the lines, which is most simply effected by taking the extreme red as a starting point, and making the distances measured to the right of it positive, those to the left negative.

Experiments.—Three principal cases arise: 1st, where the opposing spectra are of equal or nearly equal lengths; 2d, where the spectrum from the grating preponderates; 3d, where the prismatic spectrum is the longer of the two. I give below for these cases the measurement made on the two primary spectra and on the actual physical secondary spectrum, adding for each of these cases the results obtained from the construction, which, for a reason hereafter to be mentioned, are generally somewhat more correct than those obtained with the telescope.

1st Case.

Spectrum from flint glass prism of 60°.

Ka		Li		Hα		Na		Th		Hβ		Hg^3		Hγ		Hg^1
	4·5		·9		4·8		5·6		6·7		9·9		·3		10·6	

Spectrum of 1*st order, grating No.* 2.

Hg^1		Hγ		Hg^3		Hβ		Th		Na		Hα		Li		Ka
	4·75		·2		6·45		6·45		7·1		8·75		1·85		12·5	

Actual secondary spectrum due to the above in combination.

Th	Hβ	Na	Hg^3	Hγ	Hα	Li	Hg^1
·4	1·3	2·1	·3	1·5	1·05	2·75	

Secondary spectrum from construction.

Th	Hβ	Na	Hg^3	Hγ	Hα	Li	Hg^1	Ka
·25	1·25	2·2	·1	1·65	·95	3·25	4·75	

The magnifying power of the observing telescope was about 12 diameters.

2d Case.

Spectrum from bisulphide of carbon prism of 60°.

Ka	Li	Hα	Na	Th	Hβ	Hg^3	Hg^1
4·6	·8	5·4	6·3	8·	13·3	15·4	

Spectrum from grating No. 1, 2*d order.*

Hg^1	Hg^3	Hβ	Th	Na	Hα	Li	Ka
6·5	9·3	8·7	9·5	11·8	2·7	17·1	

Actual secondary spectrum due to the above.

Hβ	Th	Na	Hg^3	Hα	Li
·6	3·5	0	6·7	1·7	

Secondary spectrum from construction.

Hβ	Th	Na	Hg^3	Hα	Li	Hg^1	Ka
·7	3·2	·1	6·3	1·9	·7	11·8	

The magnifying power of the observing telescope was about five and a half diameters.

3d Case.

Spectrum from bisulphide of carbon prism, 60°.

Ka	Li	Hα	Na	Th	Hβ	Hg^3	Hg^1
10·1	2·	11·35	13·45	17·6	28·35	33·85	

Spectrum from grating No. 1, 1*st order.*

Hg^1	Hg^3	Hβ	Th	Na	Hα	Li	Ka
7·6	9·78	9·5	10·7	13·25	2·85	19·	

Actual secondary spectrum from the above.

Na	Hα	Th	Li	Hβ	Hg^3
1·9	·8	·13	7·87	18·2	

(*The same repeated.*)

Na	Hα	Li	Th	Hβ
1·7	1·	·2	7·6	

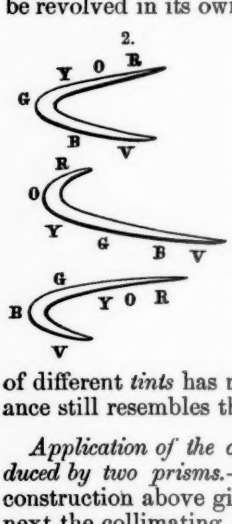
Secondary spectrum from construction.

Na	Hα	Li	Th	Hβ	Ka	Hg^3	Hg^1
1·9	·85	0	8·1	·8	17·77	26·25	

The magnifying power of the observing telescope was about 12 diameters.

The difference between the two *actual* secondary spectra in this last set of experiments is due to slight errors in adjusting for the position of minimum of deviation at the time of combination, as a small error in this respect produces, as I ascertained by direct experiment, a much larger one in the secondary spectrum. Also the differences between the set of actual secondary spectra, and those given by the formula, are mainly to be attributed to this same cause. The accuracy of the measurement in the second set of observations is somewhat inferior to that in the other two, owing not only to the low magnifying power, but to the employment of a rather awkward method for obtaining the positions of some of the lines. The maps of the spectra in last set are, on the other hand, free from this reproach.

In this place I will mention a beautiful and instructive experiment, which reveals at a glance the nature of the secondary spectrum which happens to be under examination, and permits its study in a qualitative way. Instead of using as the source of light a slit, let a pin-hole be employed, and the refracting edge of the prism being vertical, the diffraction grating is to be revolved in its own plane, somewhat, so that its lines shall no longer be vertical. This proceeding reduces the secondary spectrum to a line, and upon viewing it with the naked eye or with the observing telescope, it will be found to be curved, and upon slightly rotating the grating or prism around their vertical axes, will run through all the changes that under the circumstances are possible, as is roughly indicated in fig. 2. From this figure it will be seen, that we must regard as a true secondary spectrum a resultant spectrum in which any two, even closely adjacent lines, are united; even although the actual union of different *tints* has not been effected, and the general appearance still resembles that of one of the primary constituents.



Application of the construction to the secondary spectrum produced by two prisms.—Although it has been shown that the construction above given applies to the case of a prism placed next the collimating telescope when balanced by a diffraction grating placed next to the observing telescope, it by no means immediately follows that, by reversing their respective positions, results would be obtained which could be accurately predicted

by the construction, or by the formula founded on it. One of the disturbing causes here introduced is the thickness of the prism, which in the other mode of arranging the apparatus is indifferent. To determine the amount of the difference due to an exchange of the position of the prism and grating, I made a few experiments which may now be detailed.

The diffraction grating No. 1 was placed next the collimator, and balanced with the bisulphide of carbon prism of 60°; both were arranged for the minimum of deviation of the sodium line, and the secondary spectrum A was obtained. The whole apparatus was then re-arranged, and the same experiment repeated, with the result given in B.

	Na		Hα		Th		Li		Hβ		Hg^3	
A		1·9		·8		·1		7·6		17·2		
	Na		Hα		Th		Li		Hβ		Hg^3	
B		2·		·65		·33		7·48		17·1		

On comparing these secondary spectra with those obtained in the 3d case, it will be seen that the differences are not larger than the necessary errors of observation, except in the distance between Hβ and Hg^3, where the difference is about twice as great as it otherwise ought to be. A second perfectly similar experiment was now made with flint glass prism and grating No. 2, with the result given in C.

	Th		Hβ		Na		Hg^3		Hα		Li		Hg^1	
C		·3		1·3		2·25		1·75		1·1		2·85		

On comparing this secondary spectrum with that obtained in case 1st, it will be seen that it is even more closely correspondent than A and B. Other experiments were also made where the positions of the prism and grating were repeatedly interchanged, and the maps of the secondary spectra *immediately* compared, and from this work it results, that for *practical* purposes such exchange may be made without the introduction of serious errors, and that hence the above construction, practically, applies to the secondary spectrum furnished by *two prisms* of different materials.

It is thus seen that the construction furnishes a simple means of determining the size and arrangement of the secondary spectrum furnished by two prisms of selected angles, placed in any desired positions relative to the incident ray and to each other, the accuracy of the result depending mainly on the exactness with which the measurements on the primary constituents are effected, and it may possibly prove useful, in dealing practically with the secondary spectra in optical instruments. It is hardly necessary to remark, that the use of an eye-piece provided with

cross-hairs and a micrometer screw would easily give results considerably more exact than those detailed in this article.

I may add that the construction is evidently applicable to the case where the two primary constituents do not oppose, but add, to each other's effect, and that with it, two secondary, can be treated like two primary spectra. In this last case the two secondary spectra, if equal and similar in all respects, and opposed, of course destroy each other; but what is more to the point, the construction shows that even where the secondary spectra are additive, their sum, or the total extent of the tertiary spectrum, will be smaller when the secondary spectra are dissimilar in arrangement, than when this is in both identical, though here the matter of the choice of tints for union comes into play and must be considered.

Quite large secondary spectra with lines were also obtained by achromatizing one 60° prism of bisulphide of carbon with a train of seven water prisms, and by the pin-hole method some experiments were made on the secondary spectra obtained by achromatizing two or more prisms of a given substance, placed in the position of minimum of deviation, by a single prism of the same material much inclined; these matters were, however, not pushed far enough to give results of much interest in this connection.

Columbia College, July 11th, 1873.

ART. XX.—*Notes on the Corundum of North Carolina, Georgia, and Montana, with a description of the Gem variety of the Corundum from these localities;* by J. LAWRENCE SMITH, Louisville, Ky.

THE corundum formations in North Carolina and Georgia are the second in importance in the United States that have been brought to my notice; and the one in North Carolina is by far the most interesting in this country, and perhaps of any yet known, in the extent of the formation, the distribution of the corundum, and the purity of the mineral.

This mineral was first discovered in North Carolina in 1846—about the time I was engaged in developing the geology of emery in Asia Minor and the Grecian Archipelago; and upon communicating to American geologists my discoveries in relation to the associate minerals of the emery in Asia Minor, and directing them to search for the same in connection with the corundum found in different parts of America, the same associates were discovered in connection with the North Carolina corundum as well as that from other localities.

At this time there had been discovered but one detached block, but no other specimen could be found in that locality. There the matter rested until 1865, when C. D. Smith (to whom I am indebted for valuable information contained in this paper), assistant of Prof. Emmons, geologist of North Carolina, had brought to him by one of the inhabitants of the country west of the Blue Ridge Mountains a specimen of rock which was recognized as being corundum, and on visiting the spot this geologist discovered the corundum *in situ*, and a number of specimens were collected. Since that time public interest has increased in relation to this substance, and it has been discovered in such quantities as to make it an object of interest to the arts as a substitute for emery, and very rapidly other localities were brought to light along a distance of forty miles.

The colors of the corundum as found along this zone of outcrops are blue, gray, pink, ruby, and white. Sometimes it has broad cleavage faces, and then again it occurs in hexagonal prisms. One hexagonal prism weighed over three hundred pounds. There is a difference in the cleavage and the associate minerals at different localities.

In the development in North Carolina the corundum occurs in chrysolite or serpentine rocks, and outside of serpentine it has not been found. These chrysolite rocks belong to a regular system of dikes, which have been traversed for the distance of about one hundred and ninety miles. This system of dikes lies on the northwest side of the Blue Ridge, and has a strike parallel to the main mass of the ridge, and has an average distance from the summit of the ridge of about ten miles. It continues this strike to the head of the Little Tennessee River, say from Mitchell to Macon County, one hundred and thirty miles. Here the ridge curves around the head of the Tennessee and falls back about ten miles to the northwest. In conformity with this elbow in the ridge, the disturbing force shifts to the northwest and re-appears at Buck's Creek, having the same relative position to the Blue Ridge.

The serpentine appears at intervals along this whole line of one hundred and ninety miles. There is a corresponding system of dikes traversing the southern slope of the Blue Ridge, but not so regular and compact as the system on this northwest side, nor are the outcrops so frequent. The main mass of the ridge bears no evidence of having been disturbed at all, at least none has been found. From Mitchell County to Macon the serpentine is usually inclosed in a hard crystalline gneiss, which bears rose-colored garnets, cyanite, and pyrite. After its shifting to the right it occurs in hornblendic beds and gneiss. At Buck Creek and thence southwestward the horn-

blende beds assume very large proportions, and instead of common feldspar have in them albite, making an albitic syenite. At Buck Creek (which is named Cullakenih) the chrysolite covers an area of about three hundred and fifty acres. One or two observers have fallen into the error of confounding the two dike systems, whereas they have no connection whatever. According to them the northern system cuts through the Blue Ridge at rightangles, and then turns back on the opposite side of the ridge. Now there are no such phenomena connected with these outcrops. They evidently belong to separate systems. The outcrops along the northern system occur at intervals ranging from one to fifteen miles. The belt or zone along which these outcrops occur never exceeds four miles in width on the northern side of the ridge. On the opposite side the system is not so well defined, and the outcrops are rarer.

Upon these serpentine beds there exists chalcedony, chromite on some of them, chlorite, talc, steatite, anthophyllite, tourmaline, emerylite, epidote on some of them, zoisite, and albite, with occasionally asbestus and picrolite, as also actinolite and tremolite. The corundum at some places seems to occur mostly in ripidolite in fissures of the serpentine. At Cullakenih the corundum with its immediate associates is in chlorite, except the red variety, which is in zoisite, containing a minute quantity of chrome.

Throughout all the range of rocks for the great extent referred to, corundum forms a geognostic mark of this chrysolite-rock, just as it does of the calcareous rock bearing corundum described by me in Asia Minor. They belong to the same geological epoch, and overlie the gneiss.

The closest investigation shows that the chrysolite in North Carolina takes the place of calc-rock in Asia Minor; that these are invariably the gangue rock in the two different quarters of the globe; but, as remarked above, the contiguous rock shows them both to be of the same geological period, overlying directly the primary rocks; and both of them are also identical geologically with the Chester emery formation of Massachusetts.

While all the localities of corundum and emery I have examined exhibit certain marked and prominent characteristics common to them all, and evince unmistakable evidence of geological identity, yet each locality has its peculiar characteristics. In all cases, however, the masses of corundum give evidence of having been formed by a process of segregation, as described in my memoir on the Asia Minor emery.

In Asia Minor the Gumuch-dagh emery has but little black tourmaline associated with it, and instead chloritoid in crystals or lamellæ; also its diaspore is rare, but when found is pris-

matic, affording the finest perfect crystals yet seen, from which M. Dufrenoy made his last study of the crystallography of this mineral; and the emery is associated with calcareous rock overlying gneiss. The Kulah emery from the same part of the world is equally in calcareous rock, and has very little chloritoid or chloritic mineral associated with it.

The Naxos and Nicaria emery of the Grecian Archipelago is also in connection with calcareous rock, but has no chloritoid associated with it, but in its place black tourmaline is abundant.

While in the above localities the rock bearing the corundum is calcareous, that in Chester, Mass., has hornblendic gneiss immediately on one side of the vein, and is accompanied with a large amount of magnetic oxide of iron. Tourmaline also abounds in this corundum, and like the Asiatic variety it contains rutile, ilmenite, etc.

In the localities forming the subject of this memoir the following minerals are deserving special notice.

Corundum.—This mineral occurs in finer and more beautiful variety than in any yet known locality. The masses in many instances are very large, weighing six to eight hundred pounds, having fine large cleavages, and are remarkably free from foreign ingredients. The crystals are also fine, and in some instances of great size and beauty. Two of them discovered by Col. Jenks, and now in the possession of Prof. Shepard, have been described by him.* They are respectively three hundred and twelve and eleven and three-fourths pounds in weight. The largest is red at the surface, but within of a bluish-gray. The general figure is pyramidal, showing, however, more than a single six-sided pyramid, whose summit is terminated by rather an uneven and somewhat undefined hexagonal plane. The smaller crystal is a regular hexagonal prism, well terminated at one of its extremities, the other being drusy and incomplete. The general color of this crystal is a grayish-blue, though there are spots, particularly near the angles, where it is of a pale sapphire tint. Its greatest breadth is six inches, and its length over five. Some of the lateral planes are coated in patches with a white pearly margarite.

The smaller crystals are often transparent at their extremities. It is, however, in color that the corundum of this locality excels. It is gray, green, rose, ruby-red, emerald-green, sapphire-blue, and all intermediate shades to colorless. Many pieces of the blue and red have been cut and polished, presenting very good characters as gems, without being of the finest quality.

* This Journal, III, iv, 109, 175, (1872), in an elaborate memoir "on the Corundum region of North Carolina and Georgia."

Diaspore.—While this mineral is found so abundantly with the corundum of Chester, Mass., I have not been able to find it with the North Carolina corundum. Several specimens of supposed diaspore have been submitted to me, but on close examination it was found to be colorless cyanite.

Chlorite.—This mineral abounds in this locality, and, as has been stated, is the gangue-rock of the corundum; it not only surrounds the corundum, but permeates it. There are several varieties, varying in color from a yellowish-green to a dark-green, and differing a little in composition. Two specimens from the same locality were composed as follows:

	Large plates.	Friable.
Silica	27·00	29·15
Alumina	21·60	10·50
Oxide of iron	16·63	23·50
Magnesia	22·00	25·44
Water	12·30	10·04

Margarite (*Emerylite*).—This curious mica—curious so far as that since my first pointing it out as a characteristic of the emery formation in Asia Minor and the Grecian Archipelago it has been found wherever corundum is, and in the case of Chester emery was the means of leading to its discovery,—at the N. C. localities is abundant mixed with the associated minerals. Chemical analysis was made of a specimen with the following result:

Silica	32·41
Alumina	51·31
Lime	10·98
Soda	2·43
Water	2·13

Zoisite.—This mineral occurs in two forms—a black variety and a light-green variety. These minerals have been called by some Arfverdsonite, but neither of them have the composition of that mineral. Their compositions were as follows:

	Light green.	Lake Geneva.	Black variety.
Silica	45·70	43·59	45·90
Alumina	24·01	27·72	13·34
Peroxide of iron	4·56	2·61	11·46
Lime	13·44	21·00	12·20
Magnesia	8·03	2·40	12·53
Soda	2·91	3·08	3·39
Water	·60	----	·66
Oxide of chrome	·52	----	----

The green variety has a very pale chrome-green color; for comparison the analysis of a similar specimen from Lake Geneva is annexed.

Andesite.—This mineral occurs mostly in a granular form. Its composition is—

Silica	64·12
Alumina	24·20
Soda	9·28
Lime	2·80
Oxide of iron	·14

The other minerals associated with this emery formation are magnetic oxide of iron, chrome iron, rutile, asbestus, talc, actinolite, black tourmaline, chalcedony, anthophyllite, spinel, albite and picrolite.

On the existence of the Ruby and Sapphire in North Carolina and Montana Territory.

The corundum locality that I have described in North Carolina furnishes masses of corundum from which small pieces can be detached, of good blue or of ruby color, perfectly transparent, and nearly free from flaws. When cut and polished they are gems of no mean value. I have not seen the most perfect of them that have been cut, but I have some polished specimens of fine color but with many flaws.

The question naturally arises, what may be the prospects of obtaining the gem from that locality in sufficient quantity to warrant exploration? Up to the present time its occurrence is so different from those in known localities in the East Indies that we are rather inclined to the opinion that it will only be occasionally that pieces of corundum will be found of sufficient purity and beauty to be of much value as gems; for it is well known that very small defects, if they do not destroy altogether the value of the gem, depreciate its value to a very great extent.

About a year ago a quantity of rolled pebbles were sent to me from the territory of Montana, which upon examination I found to consist principally of corundum; they were like the rolled pebbles from the ruby localities in the East Indies, each one being a little crystal in itself, more or less abraded on the angles, and being of a compact, uniform structure. They were flattened hexagonal prisms with worn edges. They were either colorless or green, varying in shade from a light to a dark-green; some were bluish-green, but none red; there were some red pebbles, but on examination they proved to be spinel.

These pebbles are found on the Missouri River near its source, about one hundred and sixty miles above Benton; they are obtained from bars on the river, of which there are some four or five within a few miles of each other. In the mining region of this territory on these bars considerable gold is found, it having been brought down the river and lodged there, and the bars are now being worked for the gold. The corundum is

found scattered through the gravel (which is about five feet deep), and upon the bed-rock. Occasionally they are found in the gravel and upon the bed-rock in the gulches from forty to sixty feet below the surface, but it is very rare in such localities. It is most abundant upon the Eldorado bar situated on the Missouri River about sixteen miles from Helena; one man could collect on this bar from one to two pounds per day.

I have had some of the stones cut, and among them one very perfect stone of three and a half carats, and of good green color, almost equal to the best oriental emerald.

My opinion is that this locality is a far more reliable source for the gem variety of corundum than any other in the United States I have yet examined.

Art. XXI.—*The Geology of the Bosphorus.*

[The following notes are the result of a careful investigation of the rocks of the Bosphorus, made in company with Mr. W. T. Forbes, Instructor in Mathematics in Robert College.—George Washburn.]

The straits of the Bosphorus conduct the waters of the Black Sea into the Sea of Marmora. The general direction of the stream is from N.E. to S.W. Its length is about eighteen miles and its average width about one mile. Its depth is about the same as the height of its banks, which rise abruptly from its shores from two hundred to six hundred feet. These banks are broken by narrow valleys and steep gorges at right angles to the course of the Bosphorus. This broken, hilly country extends inland for many miles on both sides of the straits.

The general character of the rocks is the same on both sides, but changes suddenly near Kavak, about six miles from the Black Sea, and again in the midst of old Stamboul at the mouth of the Marmora. The bleak and barren rocks above Kavak are such as might be seen if a passage were cloven through Mt. Vesuvius, and this volcanic region extends, with irregular boundaries, about six miles east and about fourteen miles west of the Bosphorus. Below Kavak, as far as the Sea of Marmora, there are stratified rocks of the Paleozoic age, which extend inland about sixteen miles on the European shore, and about twenty-five miles on the Asiatic. They are bounded on the former by Tertiary strata, and on the latter by Cretaceous.

The Paleozoic rocks.—These rocks were formerly called Silurian. M. Roemer afterward claimed that they were Upper Devonian. Tchihatcheff in his work on Asia Minor, Dr. Abdullah Bey in various articles in German scientific journals, and Mr.

Swan in an article published by Murchison, express the opinion that they belong to the Lower Devonian. This is now the generally received opinion. It is based upon the fossils found by these gentlemen, chiefly at Caudlija, Arnaout Knie and Cartal, on the Sea of Marmora; but even in these localities many fossils have been found which are rather characteristic of the Upper Silurian period, and the rich deposits which have been discovered by Mr. Forbes and myself at Hissar and Baltaliman appear to belong chiefly to this earlier formation, although they contain fossils usually considered as Devonian.

It seems probable, upon the whole, that in this vicinity there was no clearly marked separation between the Upper Silurian and the Lower Devonian periods; our fossils belong distinctly neither to one nor to the other, but rather to a transition period between the two. Dr. Abdullah Bey, in a notice of our investigations, lately published, acknowledges that the deposits discovered by us at Baltaliman are probably Silurian. He says: "Looking at the peculiarities of the local fauna of Baltaliman, we think that this must be considered in a different light. Its enormous richness in trilobites, which approach the forms characteristic of the Silurian formation, permits us to believe that we find ourselves here at the limit where the Upper Silurian formation is in immediate contact with the Lower Devonian of the rest of the Bosphorus."

He bases his opinion, that the rest of the Bosphorus is Devonian, upon the fact that de Verneuil, the distinguished geologist of Paris, examined a large number of his specimens and pronounced most of them Devonian; but even Verneuil acknowledges that some of them were characteristic of the Silurian period—that "there seems to be no clear line of demarcation between the Upper Silurian and the Lower Devonian." "The fossils and rocks of the Bosphorus have a remarkable resemblance to the Silurian deposits of Bohemia." Tchihatcheff notices that he has a specimen from Caudlijah upon which are found a Devonian brachiopod (*Chonetes sarcinulata*) and a Silurian trilobite (*Phacops longicaudatus*). We have ourselves a single specimen three inches square found at Baltaliman, which exhibits a perfect pygidium of *Phacops longicaudatus*, a *Pleurodyctium problematicum* and a *Spirifer subspeciosus*. These admissions of Abdullah Bey, de Verneuil and Tchihatcheff, and these facts, certainly confirm the views expressed above as to the age of the rocks of the Bosphorus. Another fact of at least negative value is that no trace of fish and no sufficient evidence of the existence of plants has ever been found in these rocks, both of which might be expected in the Devonian period.

The principal rocks found in this formation are sandstones, shales, and limestones, with more or less quartz either in veins

or in isolated blocks. The *sandstones* are of every variety, sometimes passing into true conglomerates, sometimes of a fine close grain, and with colors about equally varied, gray, yellow, and red predominating. The *shales* also vary in quality and color, some of them very nearly approaching slates, while others are marlites resembling some of those of the Tertiary period. All the soil which covers our hills, and is washed down to fill the valleys is formed by the disintegration of these shales, which is going on wherever they are reached by the air and rain. The *limestone* is generally of a dark blue tint veined with calcite and sometimes with quartz, often enclosing nodules of iron and often sparkling with iron pyrites. The stone varies much in texture and quality, and although generally blue, is found at various points of a black color and often of a reddish or yellow tint. In some cases the grain is very fine without any appearance of crystalization; in others the stone is so changed as almost to resemble marble; sometimes it is very hard and sometimes soft and crumbling. The better qualities, though expensive to cut, are much used for building purposes.

The *fossils* of the Bosphorus formations are found chiefly in the shales and in some kinds of the blue limestone, but very seldom in the sandstone. The stone which contains them is rarely used either for building or for lime, and consequently they are seldom found in the great quarries. The deposits on the Asiatic shore are more extended than on the European.

On the Asiatic shore fossils are abundant in the Giants Mountain, where they generally have a bright red color owing to the presence of oxide of iron. From Beicos, near the foot of the mountain, down to Caudilli they are found everywhere along the shores and on the hills, but especially at Caudlijah and Geukson. The hill between Caudlijah and Kurfess, which is crowned by a beautiful grove of stone-pines and covered by an old Turkish cemetery, is made up of fossiliferous rock, and has furnished most of the specimens of Tchihatcheff and Abdullah Bey At Geukson the best specimens came from a point about two miles back from the Bosphorus, where the Sultan has cut through a new road to his farm.

Between Caudilli and Scutari we have found nothing except on heights near Bulgurlu and on the road to Alem-dagh.

On the European shore fossils are found on the extreme northern boundary of the Paleozoic rocks near Yeni-Mahallé—also at Therapia and Kalender—but all of them in a worn state. At Yeni Kusi, Stenia, Emirghian, and in the main valley of Baltaliman we have found nothing near the shore and only here and there one on the hills, although these villages are opposite the rich deposits of Caudlijah.

But on the hills behind Hissar and in the valley beyond them, which opens into the great valley of Baltaliman, we have made our most interesting discoveries. We have wandered over these hills and valleys again and again without finding anything and with very little hope, but a more careful and determined search, to which we were led by accidentally finding a *Loxonema* in a detached rock, brought to light a quarry in the garden of the Sultan's brother-in-law, which contained rich deposits.

About two hundred feet higher than this garden and nearer the Bosphorus we found another Turkish garden, where the underlying rock was broken up last year to the depth of four feet, and this proved to be a garden of *trilobites*. While the work was going on we visited this place as often as the ugliness of the keeper could be mollified by a reasonable backsheesh, but the work was soon done, the vineyard planted, the melons growing and the *trilobites* buried.

The Turkish cemetery in front of Robert College contains rocks which furnish many fossils, but they are poorly preserved. At Arnaoutkuei there are old quarries, which furnished former explorers with most of their specimens and which are still full of fossils. No other deposits of any importance are known to exist on this side of the Bosphorus, though others may yet be found. At Kartal and Pendik, on the Sea of Marmora, the fossils are abundant and do not differ essentially from those on the Bosphorus.

Within certain limits, however, each of the principal localities on the Bosphorus is characterized by a fauna peculiar to itself. The vineyard spoken of at Hissar, for example, abounds in *Trilobites* with only now and then an *Orthis*, or a *Cyathophyllum*. The valley of Baltaliman, 200 feet below, is especially remarkable for the great abundance and variety of its *Orthids*, and the variety and beauty of its *Crinoids*, and *Trilobites* are common, but of different genera from those found upon the hill above. From the latter we have specimens of *Conocephalus*, *Bavarilla*, *Asaphus*, *Cheirurus*, *Phacops*, and perhaps others. From Baltaliman, we have a great variety of the *Cryphæus*, *Phacops*, *Conocephalus*, *Homalonotus*, including three of the *Phacops longicaudatus* and one of the *Homalonotus delphinocephalus* of great size. In the Geukson Valley on the opposite side of the Bosphorus, we have found specimens of the Homalonotus of great size—several of the *Homalonotus Gervillei*, of which we have found no trace anywhere else. This last is figured in the plates of Tchihatcheff's Asia Minor. He remarks in reference to it, that his plate is taken from a specimen found in Normandy, and that it is doubtful whether the small fragment found by Abdullah Bey really belongs to this

remarkable species. The three specimens found by us at Geukson are fully equal to the one given in his plate.

Almost all the fossils of this part of the Geukson Valley are very large and peculiar to the locality. The *Spirifer* exists everywhere, especially the *Spirifer subspeciosus*. The same may be said of the several varieties of *Pleurodyctium* especially the *problematicum* and *Constantinopolitanum;* also of several species of *Cyathophyllum*. Many varieties of *Orthoceras* and *Trochoceras* are found at Arnaoutkuei and Caudlijah; a few at Baltaliman and Geukson. We have found in all ten or twelve species, the names of most of which we do not know, but among them is the *Trochoceras Barrandei* of de Vernueil, which is probably a misnomer; it is probably a *Lituites*. The species of *Orthis* are found in all the localities, but most abundantly at Baltaliman; from this single quarry we have at least thirty species, including a number of new ones, to two of which Dr. Abdullah Bey has given the names of Mr. Forbes and myself. The genus *Leptæna* is especially characteristic of Caudlijah, where at least twelve or fifteen species exist in abundance; at Baltaliman it is hardly found at all. The *Pterinea elegans* also is common at Caudlijah and Geukson, but is not found at Baltaliman. *Rhynconella*, *Strophomena* and *Chonetes* and species of other genera abound in various localities. Crinoids and corals of many kinds, and some of them of great beauty, occur at all the points mentioned. Should we have the good fortune to receive a visit from some thoroughly competent paleontologist, we shall submit the Robert College collection to his consideration and publish a full catalogue of our specimens. At present there are many which we cannot determine.

The Eruptive Rocks of the Bosphorus.—These rocks may be divided into two groups, those which are massed at the northern extremity of the Bosphorus, and those which are found in dikes at different points in the midst of the stratified rocks. These two groups are of different ages and of different origin, and must therefore be considered separately.

It is our impression that we have at the northern extremity of the Bosphorus the remains of a true volcano. The general appearance and structure of the rocks is the same as of those about Vesuvius or Etna. We find trachyte, diorite, basalt, vast collections of conglomerate of every kind of coarseness, often composed of masses of black doleritic porphyry with other forms of rock which are very difficult to determine. These are often regularly stratified, but in other localities in immense masses, broken only by irregular fractures.

As there is no visible crater from which all these rocks could have been thrown out, nor indeed anything which looks like a

crater of eruption, we must suppose that this crater is now hidden beneath the waters of the Black Sea, possibly at some little distance from the shore. It is certain that these volcanic rocks extend out under the sea, to some distance, and there is nothing in the nature of the case to make it improbable that there was once a vast volcano there, which vomited out all the eruptive rocks on both sides of the Bosphorus as far down as Kavak, and afterward in some later convulsion of nature sank below the surface of the sea. We have found nothing in the rocks to determine at what period this volcano existed, but we think it may be asserted that it was not contemporaneous with the eruptions of the lower Bosphorus.

The only historical evidence upon the subject is the tradition of the Cyanean rocks or the Symplegades. There are certain rocks near Fanaraki which now bear this name, but without a shadow of right. These rocks are mentioned by Strabo, who alludes to the ancient story that they were floating islands. He says that in his day two islands existed at the mouth of the Bosphorus, about twenty stadia apart, one near the European and one near the Asiatic shore. The rocks now called Cyanean are on the European coast, with no corresponding ones on the Asiatic, and they have evidently been connected with the main land within a short period of time. Their geological composition is exactly similar to the nearest point of the coast which is only *fifty feet* distant, and is connected with the island by a continuous ledge of rock, with deep water on either side, but with not more than two to three feet of water above the ledge. The sea breaks here with tremendous force and has evidently worn this passage through the rocks. If Strabo ever saw the islands of which he speaks, which is doubtful, they have since disappeared, either worn away by the sea or sunk beneath its waters. Homer, in the Odyssey, says of these rocks: "These then are lofty rocks, and near them the vast wave of Amphitrite resounds; the blessed Gods call them the Wanderers: here neither birds pass by nor the timid doves which carry Ambrosia to father Jove; but the smooth rock takes away some one of them, and the father sends another to make up the number. From this has not yet any ship of men escaped, which ever has come to it; but the wave of the sea and the *storms of destructive fire* take away planks of ships and bodies of men together. The Argo alone," etc. From this passage, I think it may be inferred that the Cyanean rocks were active volcanoes, and that at least the tradition of such volcanic islands was current in the time of Homer. What is said of the birds confirms the idea, for it can hardly be imagined that birds could be caught by the islands coming together though they might be by volcanic eruption.

It is possible then that the volcanic remains at the mouth of the Bosphorus belong to the present geological period, that the centers of eruption were already surrounded by the sea in the time of Strabo, and that they have since sunk below the surface. This seems to me, on the whole, the most plausible theory in regard to the Symplegades. They were volcanic craters that made the passage into the Black Sea extremely dangerous, and sometimes, perhaps, filled up the channel by their eruptions, thus giving rise before historic times to this well known fable.

The second group of eruptive rocks upon the Bosphorus has no apparent connection with the first. There is no evidence of any volcanic action below Yeni Mahallè. We find hundreds of dikes in the stratified rocks filled with material which is evidently eruptive, but which differs from the great volcanic domain of the upper Bosphorus in composition almost as much as in form. It is true that a few of these dikes are filled with trap, almost black, but ordinarily we find some variety of porphyry, especially dioritic porphyry. The most interesting illustration which we have of an eruption of this last is found in the valley of Bebec. In this deep gorge we can study, perhaps better than anywhere else, all the phenomena of these local eruptions, which have turned, folded and twisted the stratified rocks of the Bosphorus in such an extraordinary manner, as to make it utterly impossible to discover any regularity in the dip or strike of the strata. At Bebek there is a dike of beautiful dioritic porphyry more than 200 feet wide, which can be traced for at least half a mile, although there are generally stratified rocks above it, which have been modified in texture, twisted and rolled back by this eruption. Smaller dikes appear at other points at Bebek, so that it is not improbable that the whole hill back of the village owes its elevation to this eruption. Arnaoutkuei, Hissar, Koulali and Geukson, indeed all the prominent points on the Bosphorus, furnish equally manifest, though not always equally interesting, examples of these eruptions. In many cases the eruptive rock has decomposed much more rapidly than the stratified rocks about it, and in different localities it may be seen in every stage of decomposition, until in some cases it is distinguishable from sand or clay only by the few crystals of feldspar or amphibole which it contains. At Geukson the great extent of this eruptive rock, which is exposed by a new road, makes it almost certain that it underlies the whole hill, and we have here the curious phenomenon of well-preserved fossils in perpendicular strata lying directly against the porphyry.

It is an interesting fact in this connection that the Paleozoic domain which has been so completely broken up by volcanic

action, has enjoyed since historic times a long immunity from earthquakes. Many earthquakes have been recorded in Constantinople, some very severe, but they have spent their force on the region of the Tertiary formation and on the adjacent southern slope of Stambool, never, so far as we can learn, doing any serious damage on the Bosphorus. The walls and towers of the castles at Hissar remain unshaken, while the old walls of the city have been split and cracked in every direction.

The Mines of the Bosphorus.—These are of iron and copper. There is an iron mine, formerly worked, not far from the village of Beicos on the Asiatic coast, and a copper mine at Sariya on the European shore, now worked by an Englishman, who sends the ore to England to be smelted there. This most interesting mine is situated just at the point where the volcanic rocks of the upper Bosphorus end and the Paleozoic rocks commence. On one side of the valley you have absolute barrenness and desolation, on the other the luxuriant and picturesque scenery which has made the Bosphorus so famous. The locality of the mines is marked by groups of hills—white, red, and yellow—which are perhaps mostly the refuse of old mining operations, and are composed of disintegrating quartz, conglomerates, and variously-colored clays and earths. The metalliferous rocks are sometimes quartz, sometimes limestone or shales, and sometimes of a peculiar gray argillaceous stone, the character of which is difficult to determine. Those rocks all furnish pyrites of iron, copper and arsenic, and are decidedly richer than the average of English copper mines. Their extent is unknown. Thus far they have been worked only in a primitive way by running galleries into the sides of the hills, following the veins of metalliferous rock. There seems to be little doubt that these deposits are connected with the volcanic rocks, as we find traces of copper on the Asiatic shore, not opposite Sariya, but higher up in the eruptive rocks, or where these meet the Paleozoic. We find *iron* pyrite sand nodules everywhere, but there is no trace of copper below Sariya until we come to the Prince's Islands in the Sea of Marmora.

The origin of the Bosphorus.—It is evident, from the facts already stated, that what now constitutes the Paleozoic zone of the Bosphorus, a territory of about 700 square miles, rose above the seas at the commencement of the Devonian period as a single island. For ages it continued to be so. It was not until the close of the Tertiary period that it was united to the continent of Europe, although it was probably during the Cretaceous epoch that it became a part of Asia. Until its union with Europe, the Mediterranean, the Black Sea, and the Caspian were all one body of water. The Caspian was separated from the Black Sea, and its surface is now variously estimated

at from 80 to 300 feet below the level of the latter. The formation of the Thracian peninsula cut off the Black Sea from the Mediterranean, and it had to seek some outlet. Before this time the succession of local eruptions mentioned above had broken up the strata of the old Paleozoic island so as to form deep valleys in all directions. As the waters of the Black Sea rose, they found their way into one after another of these valleys until they reached the Marmora, which was then probably a lake. The rise in the Marmora cut through the channel of the Dardanelles. There is no evidence whatever of the Bosphorus having been opened by a single eruption or earthquake, or of any raising and breaking of the rocks on a continuous line. The only thing which makes the problem a difficult one is the existence of the great volcanic domain at the northern extremity of the straits. The channel of the Bosphorus passes through this a distance of more than four miles. How was this part of the channel formed? If we knew the age to which this domain belongs, we might answer this question. As it is, it must remain a matter of speculation.

ART. XXII.—*Explorations of* 1872: *U. S. Geological Survey of the Territories, under Dr. F. V. Hayden; Snake River Division.**

THE party gathered at Ogden, Utah, during May and June; and its scientists explored a considerable stretch of territory in the neighboring portions of the Wahsatch Mts.. while animals and supplies for the season's work were slowly got together.

Upheaval and folding have here proceeded on a vast scale, the main front ridge of the Wahsatch range consisting of an immense anticlinal, somewhat complicated on its front (western) face by subordinate folds, which would be apt to confuse one who passed hastily over them. Except where portions of these folds remain, the front of the ridge is here mainly composed of gneissoid rocks, showing strong westerly dips; while the crest and eastern slopes are composed of quartzites and limestones, also with strong dips but easterly ones. The general section of these upper strata is as follows:

1. Gray and drab limestones, largely siliceous	3000 ft.	Carboniferous.	
2. Ferruginous quartzites	2000 to 2500 "	Devonian?	
3. Blue and gray magnesian limestones, part pebbly	1900 to 2000 "	} Upper? and	
4. Gray calcareous shales	1000 to 1200 "	} Lower Silurian.	
5. White and ferruginous quartzite, base pebbly	1500 "	Potsdam.	

From discoveries made farther north, it became evident that at least the lower part of the limestones of No. 3, together with

* This notice has been prepared for this place by Prof. Frank H. Bradley, Geologist of the Expedition in the Snake River Division.

probably the whole of No. 4, must belong to the Quebec Group. The upper part of No. 3 may possibly represent the Upper Silurian, since the characteristic Niagara coral, *Halysites catenulatus*, was obtained by Dr. Hayden, in 1871, in Box Elder Cañon, about 25 miles north of Ogden, from a bed of limestone which appears to belong to this member of the section. The quartzites of No. 2 give no indication as to their age, but are referred to the Devonian merely on account of their relative position. The Carboniferous limestones of No. 1 are in some places quite fossiliferous, though mostly not so. On a hasty trip to the mining districts of Little Cottonwood Cañon, about eighteen miles southeast of Salt Lake City, the lower part of this series of limestones was found to include some layers containing Subcarboniferous fossils allied to or identical with forms common at Spergen Hill, Indiana.

Leaving Ogden on June 24th, the party followed the roads running north along the base of the Wahsatch Mts., crossing Bear River just below the point at which it breaks through the range, and reaching the divide between the Great Basin and the Columbia drainage, at a point on the Montana stage-road, about eight miles above Malade City. As we pass northward, the range loses much of its elevation; and, about Malade, the upper strata disappear, while the mass of the mountain is composed of variously-colored limestones, with intercalated shales and sandstones, most of which contain very numerous Trilobites, Brachiopods and other fossils characteristic of the Quebec Group. Mr. Meek is of the opinion that the fossils, so far as studied, will not justify a reference of the beds to an horizon higher than what has elsewhere been called Calciferous, though he admits the impossibility of distinguishing certain pygidia, which are rather common in one of the lower layers, from those of *Bathyurus Saffordi*. About 2,000 feet of strata are here exposed: and it is probable that more detailed study than it was possible to give, at the time of our visit, would show a distribution of species in the successive layers which would correspond with progress in time during their deposition. As Malade City is only a few hours ride by stage from Corinne, it is to be hoped that collectors, who may be passing over the Central Pacific R. R., will visit the locality and work out the details of the section.

The terraces surrounding the Salt Lake Basin, of which thirteen were counted near the mouth of Ogden Cañon, where the river currents had been checked by the lake when at its higher levels, though only three are prominent along most of the border of the basin, run above Malade City; and the uppermost one apparently coincides so nearly with the summit of the divide as to leave one in doubt whether or not there was

formerly a dribbling outflow from the Great Basin to the Columbia. There certainly was not any very *abundant* outflow at this point: but, from all reports, large outlets did exist, from the head of Malade River across to Bannock Creek, and from Bear River, by the way of Red Rock Pass, to Marsh Creek, a tributary of the lower part of Port Neuf River. Still another outlet existed, though it probably had but small volume, from the bend of Bear River Valley, near Soda Springs, across to the head of the Port Neuf. These should be examined in detail. In descending Marsh Creek, two terraces are very prominent; and a third is dimly outlined at about a thousand feet above the stream.

On reaching the Port Neuf, we first encounter the volcanic rocks which have filled the great plains of the Snake River Basin. The valley of the Port Neuf is floored with basalt, which escaped from one or more old craters near the bend of Bear River, and flowed between sixty and seventy miles, at least, if it did not indeed extend itself far beyond that, over the plains of the Snake. In the upper cañon of the Port Neuf, the stream flows on or in the lava beds, being constantly broken, at short intervals, by small falls over dams of calcareous tufa deposited from numerous springs along its course: but, in the lower cañon, it has fewer breaks, and runs mostly in channels excavated in the Quebec Group limestones and Potsdam quartzites of the adjoining hills, while the basalt stands as a high table in the center of the valley, broken only at the edges, where the stream has partly undermined it by removing the gravel of the old stream bottoms over which the lava originally flowed.

As we reach the plains, we find them underlaid by from three to five layers of basalt separated by beds of sand and gravel, showing as many repetitions of the volcanic eruptions, occurring after long intervals, during which intervals the mountain streams brought down and distributed widely over the plains immense amounts of well-rounded pebbles and sand, consisting mainly of quartzites, limestones and metamorphic rocks, but including also some of the lavas themselves. Upheaval has gone on here until a very recent period; since upturned porphyries and basalts, interlaminated with Pliocene sandstones and limestones, occur at many points along the foot-hills bordering the plains; but such disturbance seems to have now nearly or entirely ceased.

Reaching Fort Hall on July 3d, wagons were "turned in," a pack train was outfitted, fresh supplies were secured, and the party started again, on the 12th, across the broad lava plains to the northward, leaving for a time the Paleozoic rocks which form the mountain ranges and which are overlaid (unconforma-

bly?), about Fort Hall, by Jurassic limestones and sandstones and by the Pliocene rocks aforesaid. Vast accumulations of drifting sand cover portions of this eastern edge of the great plains, driven by the southwest winds which sweep up the valley for a large portion of the year.

Crossing Snake River, at Taylor's or Eagle Rock Bridge, the stage-road was followed to Market Lake, where the party bid adieu to civilization and struck out into the mountains. At the junction of Henry's Fork with the main Snake, two crater cones were found, standing upon the river bottoms within walls of basalt which bound the immediate valley of the present stream, and so evidently of comparatively modern date. The cones consist almost entirely of tufaceous sandstone, apparently formed under water, and inclosing many pebbles which evidently came from one of the beds of river gravel under the basalt, through which the eruption took place.

The Sand Hill Mts. were visited, and gave some evidence of having been once a volcanic crater, though the bounding walls are now so much broken down as to make their original continuity somewhat doubtful

In approaching the Teton Mts., the basalts, which are, in some parts, cut up by cañons 700 feet or more in depth, were left behind; and more ancient porphyries formed the foot-hills of the range. The axis of the range was found to consist of granites, gneisses and schists, overlaid unconformably by from fifty to seventy-five feet of compact ferruginous quartzite, supposably of Potsdam age, followed by about 300 feet of partly compact, partly shaly, glauconitic sandstone, and about 400 feet of blue, impure, thin-bedded and partly shaly limestones, both belonging to the Quebec Group. These limestones yielded a few small Trilobites. They are followed by about 600 feet of a heavy-bedded, drab to light buff, vesicular, magnesian limestone, containing no fossils except small fragments of crinoid stems, but referred with little doubt to the Niagara Group. This is followed immediately by over 2000 feet of compact, gray to drab, Carboniferous limestone, often quite cherty and mostly rather barren, though a few beds are rich in fossils.

Among the metamorphic rocks of the axis of the range, the most interesting bed is one of trap, some 60 or 70 feet thick, regularly bedded between layers of granite, laminated rather than columnar, and supposed to have been deposited by outflow over the ocean bottom during the accumulation of the original sediments of which the granites were formed. The great age of the bed, at least, is proved by its outcrop being covered, at one point, by the Potsdam quartzite, which shows no sign of disturbance; so that it *cannot* have taken its pres-

ent place as an *intrusive* rock, since the commencement of the Paleozoic. The metamorphic rocks are exposed throughout an area about thirty miles long and perhaps four miles wide. From this, the newer beds dip away in every direction, at angles varying from 15° to 30°. No disturbance of the porphyries at the foot of the range was observed, which should have given evidence of any upheaval of the range continued to modern times.

The Big Teton, named Mt. Hayden by our party, in default of any previous specific title, was found, by angular measurement, from well-determined barometric bases, to be 13,858 feet high. An attempt to carry a mercurial barometer to the summit failed of success: the reported reading of a good aneroid, at the highest point attained, indicated an elevation of 13,400 feet.*

The summits of the range are far from being "snow-covered," as reported; but huge banks of snow must last through the summer, in the various hollows of the mountain; and, in a few places, incipient glaciation was observed, though no true glacier was found, and probably none exists at the present day. In former years, however, glaciers of great size formed on these flats and in these hollows, and swept down the valleys on either side of the range, as is shown by the polished and striated rocks in the heads of the valleys, as well as by the numerous large and small boulders which line their lower courses.

Leaving the Tetons, after far too brief an examination to be at all satisfactory, though as complete as the general interests of the survey would permit, the party turned back to the valley

* This is said to have been at the summit. The writer, who reached only 12,000 feet, is not prepared to decide whether the summit was reached or not. The description of a rude building upon the crest will give the means of deciding the question, whenever the ascent shall be made by trustworthy parties. There are great discrepancies between the statements of the two persons who claim to have reached the summit. Published descriptions of the ascent are evidently enormously exaggerated, at least. (See *Scribner's Magazine*, June, 1873.) For instance, a small pond, along the route of ascent, is said to have been covered with "twelve or fifteen feet of transparent ice." Snowy ice certainly appeared over a considerable part of it, but looked so rotten that those in advance, on the outward trip, thought it not safe to attempt to cross it; and, on our return, about 4.00 P. M., Mr. Stevenson and the writer went down to the edge of the pond and dipped out cup-fulls of water for drinking. Sharp ears must those have been which heard the "hollow murmur of a creek" which "must have been twelve hundred feet beneath the surface of the snow!" The ratio of statement to fact is not constant, in the report referred to; since an eruption of Giantess Geyser, in the Upper Firehole Basin, is therein reported at "two hundred feet or more"; whereas the writer took angular measurements of that particular eruption, and found it to be a few inches less than sixty-three feet. How Grand Geyser can eject a solid column of water, "eight feet in diameter," from an orifice less than two feet in diameter, is an interesting question in hydraulics! Our author probably holds that a magazine writer should aim at *astonishing* rather than *instructing* those who are "verdant enough to confide in his stories of mountain life;" but it does not yet appear how his publishers could allow an article which in so many points plainly contradicts itself to appear in so respectable a magazine.

of Henry's Fork, and followed the general course of that stream to its source in Henry's Lake. The central portion of the valley is constantly floored with basalt, which was finally traced to its source in Sawtelle's Peak, which stands on the south side of Henry's Lake. The crater of this ancient volcano is still from 1200 to 1500 feet deep, about a half mile wide and something less than a mile and a half long. The range running west from this point appears to consist of volcanic rocks; and probably a row of similar craters will be found along its summit.

The foot-hills and mountains along the east side of the valley of Henry's Fork, after we pass the northern termination of the Tetons proper, consist of porphyries and obsidian-sandstones, until we reach the very head of the valley, a little north of east from Henry's Lake, where the same series of limestones and quartzites that we saw at the Tetons again appears in the divide between the waters of the Snake and those of the Madison; but, instead of the conformity before observed, the Quebec Group limestones apparently lie unconformably over the upturned edges of the Potsdam quartzites. Beneath these, metamorphic rocks form the face of the ridge to the westward and northward. The ridge west of the lake is mainly composed of metamorphic limestones with quartz bands, which are supposed to be of Carboniferous age. These include a sixty foot bed of trap, standing conformably between the upturned layers of the limestone.

The divide toward the Madison rises into a rather lofty range, whose height was not ascertained, but which must reach at least a thousand feet above the average level of the plateau of volcanic rocks which fills the broad depression toward the Tetons. In crossing here to the waters of the Missouri, one has the choice of three easy passes, all level enough for a horse to cross with a buggy, at full trot, and only one of them at all obstructed by timber. Henry's Lake was found to have an elevation of 6492 feet; from its southwestern side, Red Rock Pass crosses to the head of Beaver Head Fork of the Jefferson, at an elevation of 7271 feet; from its northern extremity, Reynold's Pass leads to the lower Madison, with an elevation of 6911 feet; Tyghee Pass, with an elevation of 7063 feet, led our party eastward into the basin of the Upper Madison.

The upper cañon of the Madison shows some grand scenery —vertical walls, projecting cliffs and deep amphitheaters alternating on either side of the swift flowing river of transparent water, bordered by grassy banks, and overhung by dense groves of pine and spruce. At the mouth of Gibbon's Fork, the party saw the first of the boiling springs which are so abundant in this region; and, in a few miles more, the Lower Geyser Basin of the Fire-hole Fork was reached, at about 3.00 P. M., of August 14th. Dr. Hayden's party had arrived at this appointed

rendezvous, from Bozeman, about five hours earlier, a strangely close connection for trips of a month, without communication.

The geysers of the Fire-hole have been so fully represented in this Journal, that it seems best to pass them with but brief mention, and that rather upon generalities than upon particulars.

The bedding of the volcanic sandstone which forms the mountain boundaries of the basin indicates this as probably the site of an old crater of huge dimensions, whose eruptions long since ceased, but whose fires still heat the rocks at depths accessible to the waters which readily permeate these porous strata, and which escape in springs of various temperatures up to 200° or a fraction above the normal boiling point at this elevation.

At several points, masses of this volcanic sandstone are found perforated by irregular holes, evidently formed by solution of the siliceous ingredients in the escaping hot waters. By this process, degradation of the hills and enlargement of the basin are in progress. On the other hand, the deposition of various forms of geyserite from the siliceous waters is raising the floor of the basin, in some places; though, even here, the disintegration of the laminated deposit, by the combined action of sun and frost, and its erosion by large and small streams, will, on the whole, more than equal the increase. The deposition of the solid geyserite, which is far less soluble than the silica of the surrounding rocks, gradually stops up the vents below; and the flow is thus forced back to higher levels, and so constantly removes more and more of the bordering beds.

Besides the pretty regularly laminated deposits of the more quietly flowing water, there is great variety in the forms of deposition in the more turbulent portions. The immediate orifice of a geyser is almost universally beaded; and this character extends to greater or less distances, according to the distribution of the falling water. Surfaces that are frequently bathed in steam, without much spray, are nearly always pearly, as if the steam itself carried enough silica to form the extremely thin layers which are essential to pearly luster. Surfaces constantly bathed in water, without much disturbance, are commonly covered with prickly points. In the little pools about the geysers, there are many concretions, more or less rounded below by constant attrition, and sometimes rounded also above, by constant rolling; but, more generally, the upper surfaces, and occasionally all, are roughened into very various beads and points. In nearly every pool, except where ebullition is so strong as to break up such tender tissues, there are gelatinous vegetable forms, sometimes in broad thick sheets, sometimes in clumsy branching forms resembling sponges, sometimes in long waving fibers. The former kinds are generally either green or

rusty-brown, and are most abundant in pools of comparatively moderate temperatures; while the more slender forms are commonly white, and are most abundant in the rapidly-flowing outlets of the hot pools, where they are continually reproduced as the channels fill up with newly deposited silica which buries the older fibers, so that, in breaking the crust, we frequently find laminæ filled with moulds of the fibers, sometimes so closely set as to resemble the grain of silicified wood. The only other living forms seen in the hotter pools were a few larves of *Helicopsyche*, which were found in a pool of the temperature of 180°. Very numerous skeletons of Diatoms occur in the sediment of even the hottest pools; but no living ones were found in springs of much over 100°.

The process of silicification of wood and other tissues is well shown in many cases: all stages of the process may frequently be seen in the same pool.

The eruptions of a few of the larger geysers are accompanied by violent subterranean pulsations, from 70 to 73 per minute; while others give no sound, except that of the mere rush and splash of the water.

Neighboring vents exhibit various degrees of sympathy. In some cases, a large vent is surrounded by several small ones, which are active when it is quiet and quiet when it is active. Again, the large and the small may be active together and quiet together. Large vents side by side are sometimes in full sympathy and sometimes totally independent.

Dr. Hayden's party passed down the Madison on the 20th of August; but the rest of us remained in this neighborhood while supplies were brought from Virginia City. On September 1st, we started up stream, on our return to Fort Hall. About eight miles above Old Faithful, we came unexpectedly upon another basin of hot springs, with one large geyser mound, whose observed eruptions did not exceed about seventy feet in height. On the 4th, we reached the head of the stream, and spent the next day in camp, being detained by a snow storm. On the 6th, however, it cleared; and we crossed the divide to the eastward. In approaching the head of the Madison, we had expected to find within its basin the lake seen by Dr. Hayden in 1871, and named to him by his guides as Madison Lake; but we were disappointed. We found the source of the stream, however, in a pond covering about sixty acres, to which we were obliged to transfer the name Madison Lake. Upon crossing the divide to the larger lake, we found it to belong to the Snake River drainage, and therefore called it Shoshone Lake, adopting the Indian name of the Snake.

At the western extremity of the lake, we found the valley of its principal tributary occupied by a large number of hot springs,

including several geysers of moderate size. One of these showed more plainly than common how dependent the eruptions are upon the supply of water. In this, which was called the Minute Man, a series of eruptions commences with strong jets reaching from 30 to 40 feet in height. These are repeated, at intervals of from one to three minutes, for two or three hours, gradually losing force and lengthening their intervals, until the supply of water is exhausted, when they cease for about the same period. The basin and crevices having become filled again, another series of eruptions commences. Part of the water erupted, instead of flowing away, is conducted by surface channels to the back of the geyser mound, where a large opening admits it again to the inner cavities; and, as soon as, by its flow, these are again filled to a certain point, another eruption takes place. As the supply of water gets low, eruption takes place by both vents, which indicates the end of the series of eruptions. From this it appears probable that the *constant* eruption of Steady Geyser, in the Lower Firehole Basin, is due to its standing in a large pool which keeps its cavities constantly full. The *rationale* of geyser action, as given by theorists, is not satisfactory to the writer, but he is not now prepared to fully present his own views, formed solely from observation of the phenomena. It is to be hoped that means may be found, ere long, to locate a small corps of observers in this region for an entire season, so that the details of the different forms of eruption may be fully studied. If their force and period are found to be in all cases dependent upon supply of water, as above suggested, it would be an interesting experiment to surround one of the larger geysers with a water-tight retaining wall, so that erupted water should be constantly returned, and the eruption be made continuous or dependent upon the will of the exhibitor.

Shoshone Lake is surrounded by the remnants of an old gravel terrace, reaching 112 feet or more above its present level. About the mouth of the Geyser Creek, the sand and gravel materials of this terrace are more or less firmly cemented into conglomerate, porous sandstones and perfect quartzite, by deposits from the hot springs evidently made while the lake covered the terrace, the pressure of its waters probably being sufficient to check the flow of the springs which, if not so checked, would have removed the sands instead of consolidating them. Since the decline of the lake to its present level, erosion by the springs has gone on quite extensively, and is still progressing. Perforated bits of the terrace rocks and of the surrounding volcanic sandstone, like those before mentioned as occurring in the Firehole Basins, are abundant in the crater-like hollows north of the principal springs, which also show many sulphur-vents.

Shoshone Lake is about eight miles long; and its form resembles the outline of a well-filled purse. It is apparently quite deep; but its depth was not ascertained. From its eastern extremity, a large stream flows eastward, about three miles, to another lake, hitherto unnamed so far as known, which was now called Lake Lewis, in memory of Capt. Merriwether Lewis, who would otherwise be without memorial in the region which he was the first to explore, since "Lewis's Fork" of the Columbia has now reverted to its Indian name of Shoshone or Snake River. This is about two and a half miles long and from one to one and a half miles wide. The greatest ascertained depth is 108 feet. From its southern extremity, its outlet, which was called Lake Fork, flows directly south.

Leaving the main train to move southward, a surveying party passed eastward to Mt. Sheridan, the culminating point of the Red Mts. This is about 10,420 feet above the sea, and is surrounded on all sides by deep valleys, so that wide views are attainable from its summit; 475 distinct mountain summits were counted around the horizon. It also gave fine views of all the surrounding lakes, of which a small one, Lake Riddle, lies in the summit of the divide between the Yellowstone and Lake Lewis, at an elevation of 7999 feet, while Lake Lewis itself is 7750 feet, and Yellowstone Lake is 7788 feet above the sea. The lowest point of the actual divide was located at 25 feet above Lake Riddle, or 8024 feet above the sea.

Moving southward from Mt. Sheridan, the region about the ultimate sources of the main Snake was pretty thoroughly examined, the principal streams being named, for convenience in describing and mapping. Here, at length, we escaped, for a time, from the volcanic rocks which had surrounded us ever since leaving Tyghee Pass, and found ourselves among fine-grained Tertiary sandstones. Along the waters of Barlow's River, these strata include some thin seams of coal, but of no value.

The ultimate source of the main stream of the Snake is a small pond on a flat divide between that stream and Buffalo Fork. On the west side of this divide, a sharp ridge, rising about 500 feet, shows a face of quartzite gravel reaching to its very summit, where the deposit is just pierced by an outcrop of the gray trachytic lavas and red basalt, which form the nucleus of the ridge. This is one of the highest points in the immediate neighborhood, being about 8654 feet above the sea; and there was nothing to indicate, with any certainty, what had been the source and course of the large river which had distributed such immense amounts of gravel. Only the general levels imply a southern source and a northward flow. Erosion has taken place since on so grand a scale that one is compelled to consider the deposit very ancient.

Between this point and the great valley along the eastern front of the Teton range there lies a heavy body of mountains, which appears to be the "main range" of the Rocky Mts. at this point, *if such a thing exists*. At least, it is a part of the *highest mass connection* between the Wind River and Big Horn Mts. on the east, which form the northern termination of what is the main range further south, and the range west of the Three Forks of the Missouri, which there bears the name of Rocky Mts., and whose continuation really appears to be the main range further north, so far as the best maps indicate. This, of course, does not coincide with the water-divide, which curves far north above Lake Lewis and far south around the heads of the Jefferson.

After an examination of the sources of the tributaries further west, the main Snake was again reached, about twelve miles from its source, where it is already a large stream with high gravel terraces along its banks, and was followed to its junction with Lake Fork, where the main party were in camp. A few miles above this point stratified rocks were again found, consisting of Triassic? red shades and sandstones, followed by a nearly white limestone, probably of Carboniferous age. These are at one point crossed by a huge bed of basalt, filling what had probably been a stream valley through the older rocks before the eruption of the volcanic material from some vent of the Red Mt. range. At the upper edge of this belt of basalt there is a small basin of hot springs, once of considerable importance, but now nearly extinct. Other groups were found near the mouth of Lake Fork.

In descending from Lake Lewis, the Lake Fork was found falling rapidly through a narrow cañon, whose nearly vertical walls in some places reach the height of 700 or 800 feet, while not over 400 feet apart at the top. These are all of dark-colored volcanic rock.

The low divide toward the valley of Henry's Fork was examined with some care. A large stream, Falls River, bursts full-grown from the slope of the high terrace of porous obsidian-sandstones lying north of the divide, passes through the more northern of the two Beulah Lakes, and rushes rapidly downward toward Henry's Fork. From any one of several points along the first two miles of its course, this stream might easily be turned eastward into the main Snake; and the divide on the east side of the Beulah Lakes is only eight feet above the surface of the more southern one. The rocks of the divide are all volcanic.

This pass probably affords the best line of approach to the Yellowstone from the southwest. The average grade from Henry's Fork to the summit is about 54 feet to the mile.

From the mouth of Lake Fork, the valley of the Snake widens rapidly and soon spreads out into the basin of Jackson's Lake, a body of water about eight miles long and from two to three miles wide, shallow in its eastern portions, but deepening rapidly toward the west, where the foot slopes of the Teton range descend sharply into its waters. The deepest of a very incomplete set of soundings was 258 feet.

A few miles north of the north end of the lake, the Tetons begin to rise from the flat divide of Falls River; and their slopes show Silurian and Carboniferous limestones overlying the central mass of metamorphic strata, as on the western side of the range. The Potsdam quartzite was not seen here, but is probably in place. The knobs of the central portion of the valley still show some of the volcanic rocks, though these occupy less and less space as we pass southward.

The outlet of Jackson's Lake is at its southeastern corner; and the outflow escapes into the valley of Buffalo Fork, instead of following what was evidently its natural channel through a terraced valley running from the southern extremity of the lake directly south through Jackson's Hole. This change of outlet was found to have been consequent upon the influx into the old channel of the sediment-bearing stream escaping from beneath the glacier which then filled a large two-pronged valley that here opens out of the mountains. A small lake, hemmed in by the terminal moraines of that ancient glacier, now fills the mouth of the valley. A similar lake lies before the valley which receives the entire drainage of the western side of the principal peaks of the Tetons; but it is not surrounded by any conspicuous moraines; and it is questionable whether the more abundant flow of water from beneath this glacier swept away the materials as fast as they were deposited, or whether they have been eroded by the stream since the glacier melted. Two other lakes of similar character lie in the mouths of cañons farther south, and are surrounded, the first by five and the second by three large moraines.

The Teton range, as seen from the west side of Jackson's Lake, is a grand one, rising as a wall to heights varying from 5000 to 7000 feet above the level of the plain. The snow patches were already on the increase (Sept. 24th,) and occasionally squalls would make the range really snow-*covered*, for a few hours.

Just below Jackson's Lake, Buffalo Fork emerges from the mountains, a deep rapid stream, with a broad open valley bordered by rounded hills for several miles. Fine-grained gray sandstones, probably of Tertiary age, appear near the mouth of the stream, for a short distance; but no rocks are then visible, until the point is reached, about twelve miles up stream, where

the hills on either side close in to sharp cañons, 400 feet deep by 200 feet wide, with coarse gray sandstone walls. These also are supposed to be of Tertiary age. At the head of the basin, a few miles farther on, there are high rugged walls of thin-bedded limestones and sandstones, probably of Quebec Group age, though possibly capped with Carboniferous.

The valley of the Gros Ventre, which is the first stream south of Buffalo, is narrow, with precipitous slopes on either hand, walled near its mouth by Carboniferous limestones and sandstones, which are followed above by Triassic (?) red shales and sandstones, Jurassic (?) gray and buff magnesian limestones, and Tertiary (?) white friable sandstones. A large butte which stands on the bank of Snake River, opposite the mouth of the Gros Ventre cañon, shows Carboniferous fossiliferous limestones, followed below by limestones apparently destitute of fossils, which are referred to the Quebec Group, and quartzites which are referred to the Potsdam. The southern portion of the butte shows only the soft Pliocene whitish sandstones and marls, which cover the place where we should naturally look for metamorphic rocks beneath the quartzites; but, from the strike of the upper rocks, it is probable that a metamorphic axis runs across here from the Tetons *toward, if not to*, the metamorphic nucleus of the Wind River Mts. A short distance south of this point, the metamorphics of the Teton Mts. disappear beneath the limestones which come forward from the western slope and which now form the mass of the range for several miles.

The South Gros Ventre Buttes, which stand on the bank of the Snake just below the junction of the Gros Ventre, contain the last outcrop of volcanic rocks seen in this basin. The upper slopes were not examined, in this neighborhood; and it is possible that, at a higher level, these rocks may continue southward: but the general appearance of the country gave the impression that this was their southern limit,—that, before their eruption, the drainage of the region flowed northward and escaped westward through the broad and deep valley which then existed beyond the northern end of the Teton range; that that eruption dammed up the waters over Jackson's Hole, so that the Pliocene sandstones and marls were deposited beneath the lake thus formed; and that the southern outlet across the southern continuation of the Teton range was subsequently eroded to its present level, during the progress of which erosion the terraces were formed which are here exhibited on a grand scale.

At the South Gros Ventre Buttes, the party again divided, the main train crossing the Teton Pass to Pierre's Hole, and striking the Snake again where it emerges from the mountains about twenty miles from Taylor's Bridge, while a surveying party followed the river through the so-called Grand Cañon.

This had previously a reputation for being a very difficult passage, but was found to be really very easy, compared with much that the party had already passed through. A railroad could be built here with very little difficulty. Triassic sandstones appear at the upper end of the cañon; but it is mostly walled by Carboniferous sandstones and limestones, until we pass the mouth of Salt River, a little below which the volcanic rocks of the outer basin make their appearance and follow the stream closely to the Columbia. The reunited party reached Fort Hall on October 11th, and soon after broke up. Its scientific members were the following: F. H. Bradley, geologist; G. R. Bechler, topographer; R. Hering, astronomer and meteorologist; Dr. J. Curtis, surgeon and microscopist; J. M. Coulter, botanist; C. H. Merriam, ornithologist, together with several assistants and collectors.

ART. XXIII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXVII.—*On the Minerals found at the Tilly Foster Iron Mines, N. Y.;* by E. S. BREIDENBAUGH, M.A.

THE Tilly Foster mines in Putnam Co., N. Y., near Brewster's station, on the Harlem R. R., have for a number of years been furnishing a considerable quantity of magnetic iron ore. In the spring of 1872, Prof. O. D. Allen, of the Sheffield Scientific School, in examining some of this ore at the steel works in Bridgeport, Conn., found traces which indicated that at the mine there might occur a variety of interesting minerals. On subsequently visiting the locality, Prof. Allen found specimens of a number of mineral species; and of the most interesting of these, during the past winter I have made analyses.

During the fall I paid a brief visit to the locality, finding, in the main, specimens of the same species as those found by Prof. Allen.

Formerly the mines had been worked by means of shafts, but for the past year ore has been taken principally from near the surface, and it is far less rich in minerals than that previously mined. Nearly all the specimens procured were found in a large pile of rubbish, which has been accumulating since the opening of the mine.

Except where the contrary is stated, the ordinary methods of analysis have been employed. The silica was always re-fused with carbonate of soda to ensure purity. Special care was taken to effect a complete separation of lime and magnesia from iron and alumina.

Mica.—The variety of mica most common at this locality is of a dull pearly lustre, and of a dark brownish-gray color by reflected

light, but gray with a honey-yellow tinge by transmitted light. It is in thin folia, transparent and quite tough, with slight elasticity; H.=3. The plates are compact, irregular, and show a somewhat wavy structure. It occurs lining the wall rocks. Small particles of magnetite and pyrite distributed through the plates render it quite impure. Mr. C. S. Hastings, of this School, examined this mineral for the determination of the optical characters. But on account of the wavy character of the best specimens he could only approximate to the axial divergence, finding it to be from 4°–8°. Analyses gave the following results:

	I.	II.	III.	IV.	Mean.	Oxygen.
SiO_2	40·10	40·06	----	----	40·08	21.70
Al_2O_3	14·21	14·21	----	----	14·21	7·04
Fe_2O_3	11·51	11·51	----	----	11·51	3·35
MgO	21·86	22·19	----	----	22·03	8·47
Na_2O	----	----	·39	·05	·22	
K_2O	----	----	9·73	9·74	9·73	1·63
H_2O	----	----	1·69	1·69	1·69	1·39
Fl	----	----	----	----	*tr.*	
					99·47	

Giving as the oxygen ratio for R, R, Si, 1·11 : 1 : 2·1; which is approximately that of biotite, 1 : 1 : 2.

Chlorite.—A chloritic mineral is found very abundantly, usually in the fissures and cavities of the rock; it is of a bright grass-green to pea-green color by reflected light; by transmitted light, lighter green; and in thin plates almost colorless. It has a pearly luster and is quite transparent. Thin plates are flexible, but not elastic. H.=2·5. Crystals are often quite perfect, being frequently grouped in rosettes and accompanied by crystals of chondrodite. Some of the specimens show a slight opalescence. Between the plates are found small particles of magnetite. The surface plates and edges generally show evidences of decomposition, which fact will be referred to under the white serpentine.

Mr. Hastings found the axial divergence to be 12°–14°.

Analyses gave the following results:

	I.	II.	III.	Mean.	Oxygen.
SiO_2	32·30	32·36	----	32·33	17·22
Al_2O_3	14·57	14·55	----	14·56	6·78
FeO	5·29	5·29	----	5·29	1·17
MgO	33·70	33·78	----	33·74	13·5
CaO	1·04	1·04	----	1·04	·29
K_2O	----	----	·87	·87	·14
Na_2O	----	----	·54	·54	·13
H_2O	12·01	12·04	----	12·02	10·68
				100·39	

Making for the oxygen ratio of

Ṙ, R̈, S̈i, Ḣ, 5·00 : 2·85 : 6·07 : 3·92, or for R̈R̈, S̈i, Ḣ, 4 : 3·09 : 2.

The corresponding ratios of ripidolite are 5 : 3 : 6 : 4 and 4 : 3 : 2; and hence the mineral is that species.

Associated with the above, in several specimens from this locality, is a hydrous mineral, composed of quite small foliated scales very compactly united; by reflected light it is of a dark bright green color, in the mass almost black; but by transmitted light, light pea-green. In thin plates it is translucent. The luster is pearly to resinous, and it is greasy to the feel. H.=1·5 to 2. Before the blowpipe it exfoliates, and at 4½ to 5 fuses to a grayish glass. On ignition it assumes a dirt-brown color. It is partially decomposed by hydrochloric acid. The mineral is easily crumbled into small fragments, but further reduction to a powder is accomplished with difficulty in an agate mortar. The result of an analysis was

		Oxygen.
SiO_2	37·33	21·00
Al_2O_3	7·58	3·53
FeO	9·62	2·13
MnO	*tr.*	
MgO	33·56	13·4
H_2O	11·63	9·91
	99·72	

The oxygen ratio for

Ṙ, R̈, S̈i, Ḣ, is 15 : 3 : 21 : 9, or for Ṙ, R̈, S̈i, Ḣ, 6 : 6·6 : 3.

It approaches the ratio of pyrosclerite, in which this ratio is 4 : 2 : 6 : 3 or 6 : 6 : 3. It seems to be perfectly homogeneous, and not the result of decomposition.

Serpentine.—Several varieties of serpentine are found at this locality differing much in color and structure; they usually occur in the fissures of the ore bed, either alone filling up the fissures, or in connection with chondrodite or chlorite.

In color the varieties vary from dark green to pure white. Variations in structure will be described in speaking of the several varieties. They all present a smooth, polished surface, and are generally greasy to the feel. Hardness varies from 2 to 4.

White Serpentine.—This variety is opaque white, soft (H.=2), possesses a dull pearly luster, and has a fibrous to columnar structure. Small grains are found disseminated through the ore, but it usually appears in the fissures, when it forms the matrix for rounded crystals of chondrodite and magnetite and crystals of chlorite. The chlorite and serpentine occur in all proportions not only united by contact, but in intimate admixture; and in the latter case, there is a gradual shading of color from bright green to pure white, and in texture from the folia-

tion and transparency of the chlorite to the compactness and opacity of the serpentine. Results of analyses are—

	I.	II.	III.	Mean.	Oxygen.
SiO_2	42·27	42·30	....	42·28	22·53
Al_2O_3	·85	·87	....	·86	·40
FeO	2·58	2·56	....	2·57	·69
MgO	40·29	40·30	....	40·29	16·11
CaO	1·41	1·29	....	1·35	·36
K_2O	....	....	*tr.*	*tr.*	....
Na_2O	....	....	·48	·48	....
H_2O	12·58	12·47	....	12·52	11·13
				100·35	

The oxygen ratio for R, Si, H is 17·26 : 22·53 : 11·13, or 3·1 : 4·03 : 2 ; that of serpentine being 3 : 4 : 2.

Green Serpentine.—This variety sometimes presents a quite peculiar appearance; light green and greenish white alternate in thin layers parallel to the walls of the fissure. Across the layers at a considerable inclination to them run traces of a fibrous structure; neither the layers nor fibers are separable. The layers assume a wavy appearance, depending probably on the character of the fissure. On thin edges this variety is translucent. Sometimes the color is quite dark green—again very light—with more or less distinct structure such as is described above. Analyses of this variety were made in this laboratory, by Mr. C. A. Burt, with the following results:

	I.	II.	Mean.	Oxygen.
SiO_2	41·29	41·57	41 43	22·08
FeO	2·13	2·07	2·10	·46
MgO	40·56	39·79	40·18	16·07
CaO	1·08	·82	·95	·27
H_2O	13·61	14·00	13·81	12·28
			98·47	

This likewise gives the ratio of serpentine.

A third variety was analyzed, of which only a few specimens were found. It occurs as a group of nodules, formed of radiated fibers, and is of a light grayish color with a greenish tinge and a pearly luster. Fuses at 5. H.=3. Sp. gr.=2·4.

Analysis gave—

		Oxygen.
SiO_2	39·38	21·00
Al_2O_3	1·56	·73
FeO	13·87	3·08
MnO	*tr.*	....
MgO	32·25	12·9
K_2O)	·17	....
Na_2O)	....	....
H_2O	11·90	10·59
	99·13	

Oxygen ratio for R, Si, H is hence 3 : 3·9 : 2.

One other variety of this species deserves a passing mention; it is massive, of an olive-green color, with a porcelain-like luster on the smooth fractured surface. No analysis was made.

Amphiboles.—Several varieties of the amphibole group of bisilicates appear at this locality, and are quite abundant, occuring usually along the walls of the ore bed. Of two varieties I have made analyses.

Enstatite.—This occurs massive, having a slight fibrous appearance with a pearly to vitreous luster on a broken surface, and is of a light grayish-brown color, with a yellow tinge by transmitted light. In thin pieces it is translucent. It is quite free from impurities. There is no distinct cleavage. H.=5·5. Infusible. Sp. gr. 3·29. The results given by analyses are—

	I.	II.	III.	Mean.	Oxygen.
SiO_2	54·16	54·19	----	54·17	28·87
Al_2O_3	3·35	3·25	----	3·30	1·40
FeO	9·90	9·98	----	9·94	2·19
MnO	·24	·24	----	·24	----
MgO	32·22	31·77	----	31·99	12·5
CaO	1·01	·98	----	·99	·28
K_2O	----	----	·16	·16	----
Na_2O	----	----	·32	·32	----
Ignition	----------	----	·13	·13	----
				101·24	

Oxygen ratio for $\dot{R}$, $\dot{S}i$, 16 : 29, approximately the $\dot{M}g\,\dot{S}i$ of enstatite; the composition shows it to be this mineral. If the Al_2O_3 be considered as replacing SiO_2, we have a ratio of 15 : 30·9.

Actinolite.—This variety of hornblende occurs in considerable abundance, and is generally crystalline, often only obscurely so. A few fine crystals were found. The crystallized specimens have commonly a bladed structure, H.=5·5. The color is dark green, the luster vitreous; and when free from impurities, the specimens are quite translucent—almost transparent. Small particles of magnetite and pyrrhotite are so widely disseminated through the specimens examined, even in fine crystals, that it was with great difficulty enough was obtained to make an analysis. The results obtained are—

	I.	II.	III.	Mean.	Oxygen.
SiO_2	57·39	57·50	----	57·44	29·61
Al_2O_3	1·13	1·14	----	1·13	·52
FeO	4·36	4·30	----	4·33	·85
MnO	·15	·16	----	·15	----
CaO	13·22	13·36	----	13·29	3·83
MgO	22·56	22·63	----	22·59	8·92
K_2O	----	----	*tr.*	----	----
Na_2O	----	----	*tr.*	----	----
H_2O	----	----	1·52	1·52	1·34
				100·45	

Al_2O_3 being considered as replacing SiO_2, the oxygen ratio for R, Si is 14·8 : 30·1.

Chondrodite.—Of the mineral species found at this locality by far the most interesting, with respect to both occurrence and chemical constitution, is the chondrodite, which occurs in very great abundance, small grains being widely and generally disseminated through the ore, forming what the miners term "the sand." But, approaching seams in the ore bed, the proportion of chondrodite increases, until, in the seams, fissures or cavities, chondrodite occurs crystalline with rounded crystals of magnetite and crystals of chlorite, imbedded in the white serpentine described above.

When undecomposed the chondrodite is clear, translucent, in very thin edges transparent, and possesses a vitreous luster, particularly on fractured surfaces, which are always irregular. When decomposed, as is frequently the case, it becomes opaque, grayish white, loses its vitreous luster and is easily broken, passing even into a crumbling condition.

In color, it varies from dark-brown and cinnamon-red to a light grayish-brown or yellow. Although the intermediate shades of color are found, still several varieties are so easily distinguished by color that three may be noticed. H.=5·5–6·5.

Brown Chondrodite.—This is of an amber-brown color, having by transmitted light a red tinge; the powder is light gray, and it seldom shows marks of decomposition. Disseminated through the piece which was analyzed were some small but very perfect crystals of actinolite, showing under the microscope sharply defined angles. Sp. gr. 3·2.

Red Chondrodite.—The second variety is cinnamon-red by reflected light; transmitted light gives it a yellow tinge. The powder is reddish-gray. This is the prevailing color of the crystals and crystalline specimens which were examined.

Grayish-brown Chondrodite.—The third variety has a grayish-brown color, shading into a honey-yellow, which is the prevailing color of the grains disseminated through the ore. It was found impossible to separate from the magnetite enough for an analysis, but it was proved to be chondrodite by its pyrognostic characters. This variety may be merely an altered form of the red variety. Analysis of the brown variety gave—

	I.	II.	Mean.	Oxygen.
SiO_2	35·21	35·64	35·42	18·86
FeO	5·73	5·71	5·72	1·17
MgO	54·23	54·21	54·22	21·49
Fl	----	----	9·00	----
			104·36	
Equivalent of oxygen replaced by fluorine,			3·79	
			100·57	

Analysis of red variety gives—

	I.	II.	Mean.	Oxygen.
SiO_2	----	----	35·42	18·86
FeO	9·77	9·70	9·73	2·14
MgO	51·70	52·07	51·88	20·75
Fl	5·33	5·42	5·38	----
			102·41	
Oxygen replaced by fluorine,			2·26	
			100·15	

The brown variety gives 7·3 $\dot{M}g$ and 3$\ddot{S}i$, in which part of the oxygen of magnesia is replaced by fluorine, or $MgFl_2 + 3\dot{M}g^2\ddot{S}i$.

The red variety gives 7·5 $\dot{M}g$ and 3$\ddot{S}i$.

The fluorine on the above analyses was determined by the method of Wöhler, modified by Fresenius.* The silica and bases were determined according to the method given by Rammelsberg. A large number of experiments made on these methods confirmed their superiority to others suggested during the progress of this investigation.

Mr. C. A. Burt made an analysis of a dolomite found at this locality, obtaining—

	I.	II.	Mean.	Oxygen.
FeO	·91	·49	·70	·15
MnO	·13	·64	·39	·07
CaO	30·30	29·98	30·14	8·61
MgO	20·78	20·80	20·79	8·31
CO_2	46·97	47·05	47·01	10·02
	99·09	98·96	99·03	

This corresponds to $FeCo_3$ 1·13, $MnCo_3$ 0·63, $CaCo_3$ 53·82, $MgCo_3$ 43·66 = 99·24.

The ratio of $CaCo_3$ and $MgCo_3$ is 1 : 1 nearly.

Besides the minerals mentioned above, there occur at this locality *pyrite*, chalcopyrite, *pyrrhotite*, calcite, quartz (small crystals), a few specimens of fluorite and apatite. I found also two specimens of molybdenite.

I gladly take this opportunity of expressing the obligation which I am under to Prof. Allen for his kindness in furnishing me with material for my work and advice during the progress of it.

Sheffield Laboratory, New Haven, Ct., May, 1873.

* Fresenius's Quantitative Analysis, American edition, p. 404; Zeitschr. Analyt. Chem., v, 190. Pogg. Ann., liii (1841), pp. 130–9.

ART. XXIV.—*The discovery of a new Double Star, β Delphini;* by S. W. BURNHAM.

EXAMINING β Delphini with my 6-inch Alvan Clark refractor on the evening of August 8th, I saw at once that it was a very close double star, and with a power of 410 it was well seen, although too close to be separated with an instrument of that aperture. The secondary appeared to be nearly two magnitudes the smaller. The distance I estimated to be 0″5, and the position angle about 355°. I am inclined to think the distance is slightly underrated, to the extent, perhaps, of one or two tenths of a second. It is a pretty difficult object for a 6-in. refractor; although within the last two months I have discovered a good many new double stars much more difficult, and one this same evening where the components were at least 0″2 closer.

β Delphini has long been known as a wide double star from a 11th magnitude star at a distance of 32″48 (Struve), and was first observed in 1781 by Sir William Herschel and catalogued as No. 35 of his Class IV. Struve measured it in 1829, and entered it in the great Dorpat Catalogue (*Mensuræ Micrometricæ*) as No. 2704. Sir John Herschel also noted it in his Fourth Catalogue (*Memoirs of the Royal Astronomical Society*, vol. iv), and added a more minute companion, rated by him as 14 mag., at a distance of 18″; and both were measured still later by Admiral Smyth (*Cycle of Celestial Objects*). The well known double star observer, Baron Dembowski, measured the principal companion in 1864, giving its distance as 34″64. None of these observers seem to have even suspected the duplicity of the bright star notwithstanding very much larger instruments were used than the one from which it was detected. Possibly it may prove to be a binary of long period, and single during the earlier observations. It would be very desirable to get measures of it during the present season.

Chicago, Aug. 12, 1873.

ART. XXV.—*Apparatus for Rapid Filtration;* by E. W. MORLEY.

I HAVE had in constant use for some months an apparatus that lessens considerably the time which it is necessary for the analyst to devote to a quantitative filtration. The device has become so indispensable to me, and has been so favorably received by other chemists, that an account of it may be of some value to those who employ Bunsen's method of filtration.

After fitting the platinum cone and filter in the funnel (*a*), a second funnel (*b*) of the same diameter, with a rather wide neck, is inverted over the first. A strip of thin vulcanized rubber (*c*), two or three centimeters wide, is stretched around the rims of the two funnels, so as to make a nearly air-tight joint. An elastic band (*d*) secures this strip. A syphon (*e*), inserted in the neck of the upper funnel, is made to reach below the rim of the filter, and the joint at the neck of the upper funnel is made tight by a piece of rubber tube (*f*). The outer arm of this syphon should be a few centimeters longer than the inner. The beaker (*g*) containing the liquid to be filtered is placed upon a support whose height admits of easy adjustment, so that the syphon reaches nearly down to the precipitate. A vacuum being now produced in the flask, the liquid in the beaker is drawn over into the filter, and keeps it filled to a level which depends on the amount of air entering between the rims of the funnels. If the liquid rises above this level, more liquid and less air pass the filter, the degree of exhaustion in the funnel is lessened, and the flow through the syphon is retarded. If the liquid falls below this level, the degree of exhaustion in the funnel is increased, and the influx of liquid by the syphon quickened. The oscillation of level while a clear or nearly clear liquid is passing from the beaker is only one or two millimeters. If the rubber surrounding the rims of the funnels is about twice as thick as the paper on which this page is printed, and is stretched one third or one half its length in applying it, and if the ends of the strip are pressed tightly by the elastic band, no further adjustment is needed than is made in putting the apparatus together as rapidly as is possible. In sixty seconds after moistening the filter, one may have completed the arrangement of the apparatus, and have left it to itself, to require no more attention till all the liquid above the precipitate shall have passed over.

If the precipitate is to be washed by decantation, the liquid from which the precipitate has settled is removed in the same way. When the precipitate is ready to be transferred to the filter, the beaker is raised so that the syphon reaches to the bottom of the precipitate. The precipitate then passes over, and may be completely removed from the beaker by the use of the rubber and wash-bottle, drawing the wash-water through the syphon. During this process, the action of the syphon may be hastened by closing the air passage (at *h*) by pressure, and may well be suspended at times by loosening the joint (*f*) at the neck of the upper funnel, so as to prevent particles of liquid holding precipitate in suspension from being thrown upon the sides of the funnel. If the bulk of the transferred precipitate is not too large, its washing may now be completed

by adding to the beaker a sufficient quantity of water. No further attention is required till the operation is completed by removing the upper funnel and washing its inner surface, together with the outer surface of the short arm of the syphon; on which some drops of liquid are often thrown by the bursting of air bubbles, when the level of the liquid in the beaker sinks below the end of the syphon.

The advantages of this method of filtration are—that any amount of liquid can be passed through a small filter without attention; that liquid and precipitate can be transferred with less liability to loss than by the usual methods; that the apparatus can be adjusted for use in less than a minute; and that it is composed of parts which may be said to involve no additional expense; also, that if the precipitate is not too bulky, its whole washing may be effected without attention during the passage of the wash-water.

In an experiment which was a fair sample of the use of the apparatus, the moistening of the filter and adjustment of syphon took $1\frac{3}{4}$ minutes; the passage of 380 c.c. liquid, $11\frac{1}{4}$ minutes; the transferring of the precipitate (hydrate of aluminum), using 70 c.c. water, $8\frac{1}{2}$ minutes; the passage of 85 c.c. wash-water, $10\frac{1}{4}$ minutes. Attention was given during $10\frac{1}{4}$ minutes, while the filtration lasted $31\frac{3}{4}$ minutes. In a second experiment, on the same precipitate, the apparatus was adjusted in $2\frac{1}{2}$ minutes; 500 c.c. liquid passed through in $16\frac{1}{2}$ minutes; the precipitate, with 25 c.c. of water, was transferred in $11\frac{1}{2}$ minutes, of which $6\frac{1}{2}$ minutes needed no attention; and 105 c.c. wash-water passed through in $18\frac{1}{2}$ minutes. Attention was given during $7\frac{1}{2}$ minutes, while the filtration lasted 49 minutes.

Western Reserve College, Hudson, Ohio, May, 1873.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

1. *On the reflection of Solar heat from the surface of Lake Geneva.*—L. Dufour, in a communication to the French Academy of Sciences (June 30, 1873), states that he has used the method proposed by Gasparin, of hollow blackened bulbs with a central thermometer. Three such bulbs were used; the first protected by suitable screens gave the atmospheric temperature; the second protected from the direct rays of the sun received the heat reflected from the water; the third, entirely exposed, indicated both the direct and reflected heat. Resting on the indications furnished by the three bulbs at the same moment, it is possible to fix the ratio between the heat reflected from the lake and the direct solar radiation. The calculation requisite to determine

this ratio rests on numerous preliminary experiments and upon considerations, the details of which are out of place here.

Observations were made at five stations, situated at different distances from the lake, and at various heights above its level. The two nearest stations are close on the borders of the lake; the most remote is about 400 meters in horizontal distance and at an altitude of 263 meters; all are on the northern slope of Lake Geneva (Leman), between Lausanne and Vevay.

Many circumstances unite to impair the perfect accuracy of such researches as these:—the necessity of operating in the open air, never perfectly calm; the constantly variable surface of the water; the unequal diathermancy of the air in spite of its apparent serenity; the partial absorption of reflected heat by the lower strata of the air, before the ray reaches the instrument, etc., are among the causes which prevent one obtaining perfectly regular results. These results are, however, sufficiently sharp to justify certain inferences of interest to physics and meteorology.

(1.) The highest proportion of reflected heat was 0·68 of the incident heat. This maximum was twice observed with a solar elevation of 4° 38′ and 3° 34′. A proportion between 0·4 and 0·5 of incident heat occurred a number of times at solar elevations less than 7° 27′. The proportion of 0·3 to 0·4 was frequent at solar elevations under or about 11° 56′. The proportion 0·2 to 0·3 is very naturally more frequent for elevation under or about 16° 35′. The proportion of heat reflected from water when the sun is above 30° elevation is inappreciable.

(2.) The law determining the proportion between the heat reflected and the elevation of the sun has not been satisfactorily established, owing chiefly to the changing state of the water surface, and the partial absorption of the reflected rays while traversing layers of air of variable thicknesses before reaching the apparatus.

(3.) The proportion of reflected heat arriving at distant stations does not always increase with the fall of the sun toward the horizon. For very slight solar elevations this proportion was many times less than it was at those more considerable, for the reason probably that when the sun is low its rays are reflected from distant areas of the lake, and before reaching the station have passed a thick stratum of air. The absorption which it suffers between the point of reflection and the station compensates therefore for the higher intensity due to an increase in the angle of incidence.

(4.) The proportion of heat reflected, almost without exception, is greater as the lake is calmer.

(5.) The *actual quantity* of heat reflected may be determined by taking account, at each instant, of the intensity of the direct ray and of the proportion reflected by the lake. The proportion reflected increases as the sun falls; but the intensity of the ray diminishes directly. The combination of these two opposite influences meet at a maximum corresponding to a certain elevation of the sun, which fact has been verified by many observations.

(6.) The sum total of heat which at any given station is furnished by the reflection of the lake, starting from the moment when their reflection becomes sensible, until the sun sets, may be compared to that which is presented directly by the line during a shorter period. Thus, for example, we find at the Dézaley station, on the 28th of September, reflection furnished a total of heat almost equal to that which the sun's direct rays gave during three-quarters of an hour before his setting. At the Tour-Haldimand station, Oct. 5th, this total is nearly equal to that which the sun furnished during his last half hour, etc.

(7.) Comparative observations made with the bulbs used in these experiments have served to convert their relative indications into absolute values, expressing the absolute quantity of heat reflected by the lake from one square meter of surface, normal to the ray, from the moment this reflection began to be sensible until the sun was almost set. We have the following values at—

Station:	Ouchy, Sept. 12,	104	calories.
"	Tour-Haldimand, Oct .5,	84	"
"	Dézaley, Sept. 28,	112	"
"	" Oct. 18,	134	"

These numbers are somewhat in error from the disturbing causes before named. This error certainly does not exceed a fourth of the values given, and it is very probable that the true quantity of heat furnished by reflection is greater rather than less than that stated. * * *

(8.) This action of reflected heat has no probable connection with the absence of salt in the water, and the same effects will no doubt be observed at the surface of the sea. This reflected heat is not without its influence on favorably situated plains, and it ought to affect favorably their vegetation. The loss of heat passing out of the atmosphere into the celestial spaces should by these experiments be considerable, and especially in the Austral regions where the oceanic areas are wider than at the north pole.—*Comptes Rendus*, lxxvi, 1572. S.

2. *Thermodiffusion.*—W. Feddersen has confirmed by experiment on various porous substances the theoretical proposition assumed by Carl Neumann,* that if a limited portion of a gas enclosed in a tube of unlimited length (or one that returns into itself) be different in density from the rest of the gas, an artificially-produced difference of temperature at the two ends of this portion must occasion a continuous motion throughout the endless cylinder of gas in a determined direction, and, indeed, from the cooler to the warmer end through the limited portion in question, if the gas in this be in the state of condensation. The experiments of Feddersen were performed in this manner. A substance in the form of powder was stuffed tight into a glass tube so as to form an immovable plug; this tube was fixed in a horizontal position, and the two projecting ends were each connected air tight by means of caoutchouc, with another horizontal glass tube, which

* Berichte der Königl. Sach Gessell. der Wissen., Sept. 15, 1872.

was stopped by a drop of liquid at any place in its bore. In this manner, every displacement of the air cylinder contained in the middle portion of the tubes must displace the two drops of liquid at its extremities in the same direction. One end of the plug was now exposed to a constant source of heat, the other being left cold or artificially cooled. Then without exception there appeared a slow displacement of the air column in a direction through the plug, from the cold to the heated end, sometimes quicker, sometimes slower, sometimes stronger on one side and sometimes on the other. Spongy platinum, spongy palladium, gypsum, charcoal, silicic acid and calcined magnesia, were the subject of experiment in the manner described. The detail of these experiments is given by the author in full, which cannot well be presented in abstract. From these experiments, made with the most heterogeneous substances, it appears to follow that it is a universal property of porous bodies, when in the form of diaphragms, to draw gases through them in the direction from the cold to the hot side. We have thus a phenomenon of diffusion, which, contrary to ordinary diffusion, occurs even when the same gas under the same pressure is found on both sides of the diaphragm. This is a singular, hitherto unknown phenomenon; and is properly called by the author *thermodiffusion.* Dufour* has already made diffusion observations the converse of these and in harmony with them. He states that when gases diffuse, there is a *rise of temperature* on the side where the more quickly diffusing gas enters the porous diaphragm, and *a fall of temperature* on the opposite side; so that in Dufour's experiments diffusion produces a change of temperature; in Feddersen's experiments a change of temperature causes diffusion, and the latter in a direction such that the artificially-produced difference of temperatures, if we apply the laws discovered by Dufour, is diminished by the process of diffusion itself. Accordingly there appears to be between thermo-diffusion and Dufour's discovery a reciprocity analogous to that between heat and electricity in the ordinary thermo-electric current and Peltier's phenomenon.—*Phil. Mag.*, July, 1873, p. 55, and *Pogg. Ann.*, clxviii, pp. 302–311. S.

[The influence of heat on the diffusion of gases has an illustration on a grand scale in the coking of bituminous coal in the clay retorts now so generally used in gas works. That diffusion of hydrogen and hydrocarbon and carbonous oxide gases outward into the furnace occurs is well known, and is arrested in great measure by the atmospheric exhauster, under the influence of which atmospheric air and effete gases sometimes find their way into the retorts. How far the thermo-diffusion of our author may enter as a factor into the operation of the clay retorts—which are huge porous diaphragms—remains yet to be determined.—S.]

3. *A Cyclopedia of Quantitative Chemical Anaysis;* by Frank H. Storer, A.M. Part II. pp. 113–224. (John Allyn, Boston, 1873.)—This second part of Professor Storer's important

* Archives de Genève, Sept., 1872, pp. 10, 11.

work carries the subject in the alphabet from "*Carbonate of Sodium*" to "*Cyanide of Silver.*" In January, 1871, we noticed the appearance of the first part of the Cyclopedia in terms which appears to be equally applicable to the present fasciculus.

The alphabetical order adopted appears not to hamper the author's freedom of scientific classification in the treatment of his subject. The only regret we have is the length of time, perhaps unavoidable, which is consumed in the preparation of the work, which at the end of two and a half years has not completed the letter C.

4. *Sull' Ozono, Note e Riflessioni di* GIUSEPPE BELLUCCI di Perugia. 656 pp. 12mo. 1869.—A notice of Professor Bellucci's work is deferred to another number. Other recent papers of his on ozone are—Sulla pretesa emissione dell 'Ozono dalle piante. 22 pp. 8vo. Palermo, 1873; and Nova sorgente di Ozono gl'ipocloriti. 8 pp. 8vo., Firenze, 1873.

II. GEOLOGY AND NATURAL HISTORY.

1. *The Calorific Value of the Lignites of Western America*;* by R. W. RAYMOND.—The important question of the metallurgical value of the coals of the Rocky Mountains and the Pacific Coast is to be settled, of course, by practical experiment. Meanwhile, as I have had occasion to point out, the proximate analysis of these coals throws little light upon it, and is, indeed, likely to mislead the metallurgist, if he compares it with the results of similar analyses upon bituminous and semi-bituminous coals. With the view of showing how large a proportion of the material usually classed as "volatile matters" consists of combined water, or oxygen and hydrogen presumably in chemical combination, I have collected a number of ultimate analyses from various sources, in the following tables. The numbered analyses in the first table are as follows:

No. 1. Monte Diabolo coal—Analyst, H. S. Munro, Columbia College School of Mines, New York City.

No. 2. Weber Cañon, Utah—Analyst, H. S. Munro, Col. School of Mines.

No. 3. Echo Cañon, Utah—Analyst, H. S. Munro, Col. School of Mines.

No. 4. Carbon Station, Wyoming—Analyst, H. S. Munro, Col. School of Mines.

No. 5. Carbon Station, Wyoming—Analyst, H. S. Munro, Col. School of Mines.

No. 6. Coos Bay, Oregon, Wyoming—Analyst, H. S. Munro, Col. School of Mines.

No. 7. Alaska—Analyst, H. S. Munro, Col. School of Mines.

No. 8. Alaska—Analyst, H. S. Munro, Col. School of Mines.

* A paper read before the American Institute of Mining Engineers, at Philadelphia, May 21, 1873; being also a chapter in the forthcoming Report of the Commissioner of Mining Statistics.

No. 9. Cañon City, Colorado—Analyst, Dr. T. M. Drown, Philadelphia.

No. 10. Baker Co., Oregon—Analyst, Dr. T. M. Drown, Phildelphia.

No. 11. Block Coal, Sand Creek, Ind.—Analyst, Prof. E. T. Cox.

No.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Moisture.	Ash.	Combined Water.	Calorific Power I.	Calorific Power II.	Calorific Power III.	Temperature, Deg. C.
1	59·72	5·08	1·01	15·69	3·92	8·94	5·64	17·65	5900	6472	5757	2520
2	64·84	4·34	1·29	15·52	1·60	9·41	3·00	17·46	6056	6685	5912	2536
3	69·84	3·90	1·93	10·99	0·77	9·17	3·40	12·36	6515	7172	6400	2603
4	64·99	3·76	1·74	15·20	1·07	11·56	1·68	17·10	5892	6662	5738	2512
5	69·14	4·36	1·25	9·54	1·03	8·06	6·62	10·73	6679	7264	6578	2630
6	56·24	3·38	0·42	21·82	0·81	13·28	4·05	24·55	4768	5498	4565	2313
7	55·79	3·26	0·61	19·01	0·63	16·52	4·18	21·38	4814	5766	4610	2375
8	67·67	4·66	1·58	12·80	0·92	3·08	9·28	14·40	6522	6729	6428	2532
9	67·58	7·42	-----	13·42	0·63	5·18	5·77	15·10	7439	7845	7330	2683
10	60·72	4·30	-----	14·42	2·08	14·68	3·80	16·22	5768	6760	5602	2497
11	72·94	4·50	1·79	11·77	-----	4·50	4·50	13·24	6938	7208	6843	2654

This table affords some suggestive comparisons, to facilitate which a remark or two, explanatory of its construction, will be useful. In the ultimate analysis of coals, the proportions are frequently calculated (as, for instance, in the report of 1872 of Prof. Cox, State geologist of Indiana) upon the dry coal—that is to say, excluding the percentage of moisture. Thus the analysis (No. 11 above) of the Sand Creek block coal is given in that report (p. 18) as follows: Carbon, 76·38; ash, 4·71; hydrogen, 4·71; oxygen, 12·32; nitrogen, 1·88—the previously given proximate analysis having shown 4·50 per cent of moisture. To secure uniformity in the table, I have reduced these results to the basis of a full analysis, including the moisture. The justice of including the moisture of the coal in calculations of its calorific power would be unquestionable, if the moisture were a constant element. This it is not; it varies in amount, according to the local conditions affecting the samples taken. But, on the other hand, some moisture is always present; and an amount not exceeding 5 or 6 per cent is scarcely too great to be included in an estimate of average quality. Prof. Frazer's proximate analyses of New Mexico coals give an average of 3 per cent; of the Boulder Co. coal of Colorado, 16 per cent; of the Evanston coal, 5·83 per cent; and the average of 93 analyses of Indiana coals, made by Prof. Cox, gives 5·87 per cent of moisture. Now this moisture is a greater detriment to the heating power of the coal than an equal amount of ash, since the water requires to be evaporated, while the ash does not. I have therefore included in the above table the percentages of moisture, as a basis for calorific calculations, though in several instances (notably Nos. 4, 6, 7, and 10) the amount of moisture is perhaps abnormally great, and the calorific power resulting from the calculation may be less than the average of the coal would

give. There are, it will be noticed, three columns of calorific powers. In each of these the amounts are expressed in centigrade heat units, and therefore indicate directly the pounds of water which could theoretically be raised from zero to the boiling point by the combustion of one hundred pounds of fuel. The first column is obtained in the following manner: The amount of combined water is found by adding to the oxygen one-eighth its weight of hydrogen; the remaining hydrogen is multiplied by 34,462, the number of heat units evolved in the combustion of hydrogen; and the amount of carbon is, in like manner, multiplied by 8,080, the calorific modulus for carbon. The sum of these two products is the number of heat units generated by the complete combustion of one unit of the fuel, containing the given proportions of carbon and available hydrogen. The heat units due to the combustion of the sulphur are disregarded, in view of the small amount of sulphur, its low calorific capacity (about 2,240 units), and the circumstance that it exists partly in the form of pyrites, the decomposition of which still further diminishes the amount of heat from this source, and partly as sulphuric acid, causing a net loss.

The second class of calorific powers is obtained by a similar calculation on the supposition that the moisture is absent. The third column gives the closest approximation to the available heat, and is obtained by deducting from the figures in the first the amount of heat units required to vaporize the moisture and combined water. This is 537 units of heat for each unit of water.

The last column gives in centigrade degrees the maximum theoretical *temperature* to be obtained by the perfect combustion of the fuel. It is calculated in the following manner: The quantity of carbonic acid, sulphurous acid, water and nitrogen, resulting from the combustion of one unit of the fuel in atmospheric air is determined, and the quantity of each of these substances is multiplied by its specific heat. The sum of these products, which we may call the temperature unit, is the number of heat units required to raise the mixture one degree in temperature. Dividing the number of heat units given in column III by this temperature unit, we obtain as a quotient the number of degrees centigrade through which the temperature of the fuel will be raised, or, in other words, the average temperature of the products of combustion, on the supposition that the initial temperature is zero, that the combustion of carbon and hydrogen is complete, that no superfluous air is admitted, and that there is no loss by radiation and conduction during the process. The calculation may be illustrated by displaying a single example in detail.

We have in analysis No. 1 of the table the following constitution of the fuel: Carbon, 59·72; hydrogen, 5·08; nitrogen, 1·01; oxygen, 15·69; sulphur, 3·92; moisture, 8·94; ash, 5·64. To find the combined water, we add to the amount of oxygen the proportional amount of hydrogen, or one-eighth, since water consists of one part hydrogen, and eight parts oxygen. This gives us 17·65 combined water, leaving 3·12 of hydrogen available for the generation of heat. But the moisture and combined water

must be evaporated by the combustion of the rest of the fuel; and the heat aborbed in this evaporation is 537 heat units. Hence, to evaporate 26·59 hundredths of water, will require (temperature apart) 142·78 heat units, which must be subtracted from the calorific power in column I, leaving 5757·22, as per column III, the available amount of heat.

We now proceed to determine the temperature of the products of combustion. A simple calculation based upon the chemical equivalents shows that those products will be as follows:

59·72 carbon	will unite with	159·28	oxygen, forming	219·00 CO_2
3·92 sulphur	"	3·92	" "	7·84 SO_2
3·12 hydrogen	"	24·96	" "	28·08 HO
26.59 combined water and moisture,				26·59 HO
Total oxygen required from the air,				188·16
Amount of nitrogen corresponding to this amount of oxygen in the air,				629·86
Amount of nitrogen already in the fuel,				1·01
Total nitrogen in the products of combustion,				630·87 N

The specific heat of carbonic acid—that is, the number of heat units required to raise a unit of this gas one degree of temperature—is 0·216; the specific heat of sulphurous acid is 0·155; that of steam is 0·475; and that of nitrogen is 0·244. Applying these numbers, we have for the heat rendered latent by each substance in one hundred units of the above mixture of gases:

CO_2	219·00 × 0·216 =	47·304
SO_2	7·84 × 0·155 =	1·215
HO	54·67 × 0·475 =	25·968
N	630·87 × 0·244 =	153·932
		228·419

That is to say, it will require 228·419 units of heat to elevate the total products of combustion of 100 units of fuel one degree centigrade; or, 2·28419 is the specific heat of the products of combustion of one unit of the fuel. Dividing 5757·22, the number of available heat units from the combustion of one unit, by 2·28419, the heat absorbed for each degree of temperature, we have 2,520, which is the temperature in degrees centigrade of the products. It need scarcely be said that the unit of weight employed is immaterial to this calculation. The temperature is the same, whatever the quantity of fuel, provided the combustion takes place as above supposed, and the gases are not compressed.

It should be remarked, finally, that the oxidation of iron in the ash has not been taken into account in the foregoing calculations. The analyses give no means of determining it; but it is certainly insignificant as a source of heat, and its contribution to the resultant temperature would be reduced by the diluting effect of an additional quantity of nitrogen in the air required for its oxidation.

Pure carbon yields by combustion to carbonic acid 8,080 heat units; and the theoretic resultant temperature of the carbonic acid is 2,720°. It will be seen that some of the coals in the table,

particularly the lignites of Cañon City in Colorado, and Carbon Station in Wyoming, approach the calorific power of carbon.

Moreover, several of the lignites nearly equal, and that of Cañon City surpasses, the "block coal" of Sand Creek in calorific power. Yet the latter is successfully used in the smelting of iron. We are therefore led to conclude that high metallurgical temperatures can be obtained from the best lignites of the Rocky Mountains, and that only their physical behavior, which hinders a complete combustion, prevents their use, even in shaft furnaces. That they can be utilized by means of gas producers, I think there is no room to doubt.—*Engineering and Mining Journal, May* 27, 1873.

2. *The Mineral Region of Lake Superior.*—At the meeting of the Montreal Natural History Society, held on Monday evening, Feb. 24th, Prof. R. Bell, of the Geological Survey of Canada, read a paper on the Huronian and mineral-bearing rocks of Lake Superior, of which the following is an abstract.

In addition to the sandstones of the south shore of the lake, which are unaltered sediments, in which traces of organic life have been detected, there are three well-marked groups of rocks on the Canadian side. These are the Laurentian, the Huronian, and the Upper Copper-bearing series of Lake Superior. Recent researches have shown that Huronian rocks occur, to a much larger extent than was formerly supposed, as bands alternating with Laurentian beds on both the north and south shores of the lake.

To the northward of Lake Superior the Laurentian rocks for the most part consist of gray and reddish gneiss, with micaceous belts and mica schists. No minerals of any economic value have yet been found in these rocks at this particular locality, nor do there seem to be any crystalline limestones.

In the same region the Huronian rocks are mostly of a schistose character, the most common of which are greenish schists and imperfect gneisses, the whole formation being rich in useful minerals.

In these latter deposits almost every conceivable variety of schist is to be met with. Among them are micaceous, hornblendic, dioritic, porphyritic, siliceous, cherty, chloritic, felsitic and argillaceous schists; more rarely dolomitic schists, and occasionally bands of magnetic iron ore and hematite. The lecturer stated that in this region gold and silver veins are always associated with dolomitic schists. The principal vein to the southwest of Shebandowan Lake, and others, were referred to as bearing out this statement. In the Hastings series of rocks gold is also associated with dolomitic schists.

Various isolated patches of granite and syenite, some a few yards and others many miles in extent, but always connected wiht Huronian rocks, were pointed out on the map. In these masses there is no stratification.

In the Nipigon Basin, the Upper Copper-bearing rocks of Lake Superior attain their maximum development in Canadian Territory. This area has the shape of an arrow-head, with the apex pointed to the true north. The basin floor consists of marls, sandstones, &c., often covered with trappean outflows. The lecturer

was disposed to think that this trappean outburst originated from some point in Lake Superior. The direction of the flow, as indicated by wrinkles on the surfaces of beds, is from the center outward. The occurrence of these traps on all sides of the lake, and their general arrangement, which presents an appearance as if the masses had been pressed against the rocky margin of the lake basin, are supposed to favor this view. The overflow in the Nipigon Basin too becomes exhausted in receding from Lake Superior.

Unlike the Laurentian rocks, in which, as before stated, no useful minerals have been found, the Huronian beds contain ores of iron, copper, lead, gold, silver and nickel. Copper is most frequent in quartz veins which intersect dioritic schists of Huronian age. The silver and gold veins near Shebandowan occur in similar schists, and were discovered by Mr. P. McKellar in the spring of 1871. A letter from Mr. McKellar to Prof. Bell was then read, which gave a description of the details. The principal vein, Mr. McKellar writes, is of quartz, and is from two to six feet in thickness. In addition to gold and silver it contains ores of all the metals we have cited above as occurring in Huronian rocks. At this locality, in addition to the dolomitic band associated with intrusive granite, a great variety of Huronian schists occur. A vein of calc spar and quartz cutting through Huronian schists on mining lot 3 A, on the north shore of Thunder Bay, and containing native silver and nickel ore, was next described.

The main silver vein of Silver Islet belongs to the Upper Copper-bearing series, and although it has been worked to a depth of 150 feet below the surface, no trouble has yet been experienced from flooding. Up to the middle of last summer about one million dollars worth of silver had been taken from this mine. Various other silver-bearing veins and mines in rocks of this age were described briefly, but the space at our disposal will only allow of the bare mention of their names. Suffice it to say that the Algoma, Silver Harbor, Thunder Bay Silver Mine, Shuniah, Jarvis Island, McKellar's Island and McKellar's Point deposits were each noticed. In conclusion, the lecturer said that the silver veins which intersect trappean rocks belong to two sets, one of which have a N.E. and the other a N.W. direction.—*Montreal Gazette.*

J. F. W.

3. *On the Carboniferous Myriapods preserved in the Sigillarian Stumps of Nova Scotia;* by S. H. Scudder. 10 pp. 4to. From the Mem. B. S. N. H., vol. ii, 1873.—To the species of Myriapods described by Dr. Dawson others are here added by Mr. Scudder, and the whole subject reviewed. The species include *Xylobius Sigillariæ* Dawson, *X. similis* Sc., *X. Dawsoni* Sc., and *Archiulus xylobroides* Sc. They appear to be all of the Iulus tribe, and for the family the name *Archiulidæ* is proposed. Mr. Scudder mentions the discovery of a *Xylobius* by Mr. Henry Woodward in the British coal measures at Kilmaury, Ayrshire, and Cooper's

Bridge near Haddersfield, and proposes for it the name *Xylobius Woodwardi.*

4. *Dr. Dawson on the Post-pliocene Geology of Canada.*—The four numbers of the Canadian Naturalist for 1872, contain the successive parts of an elaborate review of the facts connected with the drift and other post-tertiary deposits in Canada, by Dr. Dawson, and mostly from his own observations. The number of species of fossils collected from the post-tertiary beds of the St. Lawrence and those of the coast of Labrador, enumerated with a mention of localities in this paper, is 205; of which 24 are Radiates, 140 Mollusks, 26 Articulates and 5 Vertebrates, besides 10 of plants. Dr. Dawson observes that all, with three or four exceptions, are northern or Arctic species, belonging in the case of the marine species to depths from the littoral zone to 200 fathoms, and identical with those of the northern part of the Gulf of St. Lawrence and the Labrador coast. The shells show some amelioration of climate from the epoch of the oldest of the deposits to that of the latest, and yet but little, as the cold Labrador current continued to flow into the St. Lawrence Gulf and River.

In connection, Dr. Dawson brings out the various arguments which appear to him to sustain the Iceberg-theory, and all who are studying the subject will be interested in reading them. He closes his arguments with one of a personal nature: that certain views (which he does not discuss) of the advocates of the glacier theory, Dana and Geikie, have by their extravagance "contributed largely to the overthrow or modification of the theory." The writer would add that he has no objection to the challenge, and will only refer the reader to a paper on the subject in this Journal for March, 1873. In this recent paper, and also in the earlier referred to by Dr. Dawson, it is observed that the glacial scratches over the rocks of Canada directly north of New England correspond in direction with those south and southeast over the higher parts of all New England; showing that the ice-mass which did the work of abrasion to the north continued on its southeastward course to the ocean; and proving, therefore, that the ice was that of a glacier. This conclusion was further sustained by reference to the fact, that while the glacier-mass had a general southeastward course over New England, its under-surface often followed the courses of various New England valleys, going ways impossible for icebergs. It was added that if all was the work of a glacier, the upper surface of the glacier must have been higher about the mouth of the St. Lawrence (lat. 48°–50°) than it was far up stream (lat. 45°–48°), or else the glacier would have moved northeastward down stream. Now Dr. Dawson mentions as one strong argument in favor of the iceberg-theory, that the scratches and drift transportation in the vicinity of the St. Lawrence River were made by a movement *up stream* (such a one as might in his view have existed if the continent were deeply submerged and the St. Lawrence valley opened over the Lake region into the Missis-

sippi valley). His facts thus prove that there was *no movement down stream*, and therefore that, if the ice existed as a glacier, it *was* highest about the mouth of the St. Lawrence. He thus sustains the statement made in that paper, that any valley movement of the bottom ice along the St. Lawrence valley must have been one directed southwest or up stream. J. D. D.

5. *Report of the Geological Survey of the State of New Hampshire, showing its progress during the year* 1872; by C. H. HITCHCOCK, Ph.D., State Geologist, etc. 16 pp. 8vo. Nashua, N. H., 1873.—This report is a brief statement to the Secretary of State of New Hampshire, of the plans of the State geologist with regard to the Final Report on the Survey. The volume, according to the statements, will treat first of the Physical Geography, and include in this part a chapter by Professor Quimby on the facts relative to the terrestiral magnetism of the State from his own observations; and, secondly, of the Stratigraphical Geology. The latter part is to be followed by observations on the elevation of mountains, on Agricultural Geology, etc. Prof. Hitchcock presents as the subdivision of the rocks of the State—(1) Fossiliferous *Helderberg* limestone near Littleton; (2) The Coos group consisting of quartzite, staurolite schist, mica schist, clay slate, etc., situated for the most part near the Connecticut river, and extending nearly continuously from Massachusetts to Canada, but occurring isolated in some other parts of the State—which are referred by Prof. Hitchcock to the *Cambrian;* (3) Areas of the hydro-mica slates, conglomerates and quartzites, one north of Columbia and the other south of Stratford, and extending south along the Connecticut to Charlestown, supposed to be *Huronian;* (4) Gneissic, granitic and labradoritic rocks of the White Mountains and other areas, made *præ-Huronian.*

6. *The Fourth Annual Report on Mines and Mining;* by ROSSITER W. RAYMOND. 566 pp. 8vo. 1873.—On page 146 of this volume is a notice of Dr. Raymond's third Report of Mining Statistics, erroneously stated for 1871. The writer was misled by the title and also by the fact that the volume was transmitted by an official from Washington, as the new volume of the current year. The contents are correctly stated, only the *third* was mistaken for the *fourth* report, the title of which is here given.

The same subdivisions are adopted in this report as in the preceding. California, Nevada, Idaho and Oregon, Montana, Utah, Arizona, New Mexico, Colorado, and Wyoming, form each a separate chapter in Part I. The smelting of argentiferous lead ores in Nevada, Utah, and Montana—Economical results in the treatment of gold and silver ores by fusion—The amalgamation of gold ores—The amalgamation of silver ores in pans with the aid of chemicals—The treatment of ores of native silver in Chihuahua—The reduction of silver ores in Chili—The metallurgical value of the lignites of the West, and finally the metallurgy of native sulphur, are the titles of several chapters in Part II. The most important chapter in Part III, is devoted to American

schools of Mining and Metallurgy, in which the organization and plans of instruction are given in detail of twelve of the most important science Schools of the United States, a timely and permanently useful thing to do.

7. *Birds with teeth.*—The first example of a bird with teeth was described by Prof. MARSH, in the last volume of this Journal. At the meeting of the Geological Society of June 25th, Prof. R. Owen read a "Description of the Skull of a dentigerous Bird," which he named *Odontopteryx toliapicus*, that was obtained from the London clay of Sheppey.

8. *The Human Skeleton of the cave near Mentone.*—A brief notice of a memoir on this skeleton and its mode of occurrence by A. Rivière is given in vol. iv, at page 241. The memoir has been issued the present year by J. B. Baillère et Fils, Paris. It extends to 64 pages 4to, and contains two excellent photographs, one of the skeleton, and the other, more enlarged, of the cranium with the upper part of the skeleton. The author states that the height of the man of Mentone was about 1·85m., or 6·08 feet. It closely resembles the man of Cro-Magnon (Perigord district of France), whose height was probably over 1·80m. (5 ft. 11 in.), and also that of Grenelle whose height was about 1·70m. Calling the length of the humerus 100, that of the tibia was 76·90, while the same in the negro is 79·43 for the male, 79·35 for the female; and in the modern skeleton of the laboratory of Anthropology 73·61. The forehead is full and high, and the facial angle 85°. The skull is strongly dolichocephalic, because long, and not because narrow; and there is no prognathism or projection of the jaws.

9. *Footprints in the Middle Coal Measures at Osage in Kansas.*—Prof. Mudge has found at Osage about twenty different slabs with footprints. The impressions were made by four different species, one or more Labyrinthodonts, and others apparently true Reptilian. One of the former is about five inches broad. Two of the latter had long slender toes, and one of the two was eight inches long. The bed of rock—an excellent flagging stone—contains also some marine fossils, showing that, when the tracks were made, there was there a mud flat or shoal.—*Kansas Commonwealth, Topeka*, July 6, 1873.

10. *Geological Survey of Kentucky.*—The announcement will be received with great satisfaction that a Geological Survey of Kentucky is to be carried forward under the direction of Prof. N. S. Shaler, of that State, now Professor of Geology in Harvard College. Prof. Shaler will make the work tell on the progress of geological science, and not less on the welfare of the State.

11. *Geological Survey of Illinois.*—Mr. A. H. Worthen, the able head of the Geological Survey of Illinois, writes to the editors that the fifth volume of his Geological Report is in course of publication. It is paleontological, like the three preceding, and will contain many admirable plates of Crinoids, etc., with descriptions of species by Mr. Meek.

12. *Stromatopora.*—Dr. A. H. Nicholson, in the Ann. Mag. N. H., IV, xii, 89, has described as new four species of *Stromatopora* —one Upper Silurian and three Devonian—from Canada West, and gives reasons for regarding these coral-like fossils as calcareous sponges.

13. *Descrizione Geologica dell' Isola d'Elba*, per sevire alla Carta della medesima, di IGINO COCCHI, Presidente del R. Comitato Geologico d'Italia. 172 pp. 4to, with many plates. Firenze, 1871.—Prof. Cocchi in this memoir describes at length the geological structure of this most famous of iron-bearing lands, gives various facts respecting its productions, and illustrates the subject with a colored geological map of the island.

14. *The European Lobster, Palinurus vulgaris, in the Brighton Aquarium.*—The tank containing the Spring Lobster or Sea Crayfish, *Palinurus vulgaris*, at the Brighton Aquarium, No. 26, is invested with special interest at the present moment, on account of the appearance, during the last few days, of innumerable young. Until within late years, the early condition of this, the largest of our British Crustacea, was regarded as a distinct species, allied to *Squilla*, representing the Stomapodous instead of the Podopthalmous order of their class; it was thus described by Leach under the name of *Phyllosoma commune.* The celebrated Belgian naturalist, Prof. Van Beneden, was one of the first to establish the identity of these two forms, and the result of his praiseworthy investigations was simply and amply confirmed by the recent arrivals at the Brighton tanks. In this "*Phyllosoma*" phase, the ovate body is so remarkably transparent and flattened out, that even when several inches in length they can scarcely be distinguished at the surface of the sea, where they often float in countless numbers. Some very fine examples of these Crustacea, illustrating this interesting stage of their development, are exhibited in the typical invertebrate series in the Royal College of Surgeons. The specimens at the Brighton Aquarium just excluded from the egg are very small, scarcely exceeding half an inch in total length, and although swarming in their tank are, on account of their extreme pellucidness, only visible on the closest inspection. The "berried hen" producing this large brood of young was added to the collection about a month ago. An adjoining tank, No. 28, is teaming in a similar manner with the young of the Common Lobster, *Homarus vulgaris.*—*Nature*, July 17.

15. *Mexican Myriapods.* Mission Scientifique au Mexique, etc., Ouvrage publié par ordre du Ministre de l'Instruction Publique. Sixième partie, 2de section: *Etudes sur les Myriapods* par MM. HENRI DE SAUSSURE et A. HUMBERT. 212 pp. 4to, with 6 plates.—Messieurs de Saussure and Humbert have made in this work, as in other parts of the same series, a very important contribution to North American zoology. A previous memoir on Mexican Myriapods was published by de Saussure in 1860, and to that the reader is referred for the descriptions there given. The present volume discusses the classification and fundamental characters of Myria-

pods, enumerates the species before published, and adds descriptions of new species from other parts of America which are complementary to the Mexican fauna, and which may serve to illustrate the subject of geographical distribution. An extended catalogue of American Myriapods is added to the work.

16. BENTHAM'S *Notes on the Classification, History, and Geographical Distribution of Compositæ;* an elaborate and most interesting memoir. This commentary of the order *Compositæ*, as recently worked up in the new Genera Plantarum, fills nearly 250 pages of the 13th volume of the Linnean Society's Journal, and is also separately issued, has table of contents, and four plates. One of these illustrates the corollas, one the stamens, and a third the styles of *Compositæ*; the fourth exhibits the affinities of the tribes by a diagram. A. G.

17. A. S. OERSTED'S *System der Pilze, Lichenen und Algen.* A translation from the Danish into German, by A. GRISEBACH and J. REINKE; illustrated with 93 wood-cuts. 194 pp. 8vo. Leipzig; Engelmann. 1873.—An excellent compendious text-book of the Lower Cryptogamia, adapted to the use of ordinary classes or individual students desirous to find their way to a good general knowledge of the structure and classification of *Fungi*, *Lichenes*, and *Algæ*. The wood-cuts are very striking and tell their story with great clearness. It is much to be wished that we had something of the sort in this country, in which there is an increasing desire to study the Lower Cryptogamia, but hardly any appliances for it. A. G.

18. *Catalogue of the Phænogamous and Vascular Cryptogamous Plants of Canada and the northeastern portion of the United States;* by ALLEN H. CURTISS, Liberty, Bedford Co., Virginia, July, 1873.—The portion of the U. S included is that comprised in Gray's Manual, with the addition of Missouri and Minnesota. By careful management in plan and typography, the whole catalogue is comprised in eight large quarto pages, each of six columns, and the geographical range is indicated by noting the occurrence or not of each plant in the three most dissimilar districts, viz: 1. Canada; 2. Illinois; 3. Virginia. The varieties are enumerated, and the main synonyms. It is prepared especially for use in botanical exchanges, by one of our most active and keen botanists, has evidently cost very much time and care, and it appears to be admirably adapted to its end. A. G.

19. *A Botanical Index to all the Medicinal Plants, &c.;* by ALLAN POLLOCK, druggist. 137 pp. 8vo. New York, 1873.—This is a new edition, evidently prepared with great care and thoroughness, of a truly useful work, intended for druggists; but the botanist can hardly find elsewhere so full a collection of popular names. There is first a list of officinal plants with the popular names appended, the more proper one italicized; then one of popular names with reference to the botanical name. In one instance a name is wrongly given, evidently through a reliance on very old authority,

as when the Black Cherry or Rum Cherry is referred to *Prunus Virginiana* instead of *P. serotina.* A. G.

20. *On a new method of observing the rate of growth in plants;* by E. Askenasy, Flora, 21st May.—This is a brief preliminary communication in which the author, after alluding to Müller's use of a transparent net, and Sach's Auxanometer, describes a simple device for reaching the same end. He employs a glass tube, of convenient size, to be placed in the field of a microscope, and allows the root or other part of the plant to grow in this. Of course the part must be fixed at some point, either with cork or with damp bibulous paper. The free end of the root has now room for growth either in water or in moist air, preferably the latter. The tube can be subjected to a known degree of heat by the use of Sach's hot-air chamber (described on page 644 of the Lehrbuch). The tube having been fixed on the stage can be accurately observed every few minutes, or after a longer time, a micrometer being all that is needed for determining distances. The errors which may result from these observations are frankly alluded to. This simple method is particularly adapted to the investigation of the effect of light on growth, as the whole apparatus is completely under control of the observer. G. L. G.

21. *On the general occurrence of Starch in Sieve-cells;* by Dr. Briosi (Bot. Zeit., May 16th.—A brief recapitulation of previous researches by Hartig and Hanstein, is followed by an account of recent original observations. In all plants examined, when a violet color is produced in sieve-cells, by iodine in iodide of potassium, the requisite magnifying power shows that there are always minute granules which present a sharply defined spherical outline. Even in the so-called solutions of starch in cells, these minute granules can be detected. They remain unchanged after treatment with alcohol and ether. In sections treated according to the method of Böhm-Sachs (that is, heating with a solution of potash, washing, and neutralization with acetic acid, and then addition of a dilute tincture of iodine) the starch granules of the sieve-cells are colored deeply violet, even when the large starch granules of adjacent cells have become broken down into a paste. If the sections are placed in dilute acids (hydrochloric, or nitric) and then treated with iodine in iodide of potassium, the starch granules are colored blue, or deep violet. The minute granules swell up, but still preserve their spherical form, even when the other granules have become a paste. G. L. G.

22. *The influence of Temperature on the development of Penicillium glaucum, Blue Mould.*—Prof. Wiesner presented to the Vienna Academy, on the 24th April, a memoir on the above subject, an abstract of which appears in Bot. Zeit., May 30th. The germination of the spores (conidia) occurred between 1·5 and 43° C., the development of the mycelium between 2·5 and 40° C., the formation of spores between 3° and 40° C. Near the upper and lower limits, the germination, the growth of mycelium and the production of spores were uncertain The rapidity in the rate of

germination increases steadily up to 22° and above that diminishes, at first steadily, then without regularity. The rapidity of mycelial growth rises continuously from the lower limit up to 26° C., and then falls with more or less regularity. The maximum rapidity of the production of spores is reached at 22° C. G. L. G.

III. Miscellaneous Scientific Intelligence.

1. *On the sudden cooling of melted Glass and particularly on "Rupert's Drops;"* by V. de Luynes.—The bursting produced in "Rupert's drops" the moment the thin end is broken off has been hitherto attributed to the state of forced dilatation of the interior.

It is supposed that the external layer, suddenly solidified by cooling, while the inner portions are still hot and much expanded, compels the latter, to which it remains adherent, to retain a volume greater than that to which they would be reduced if the whole drop had been cooled slowly; hence a state of unstable equilibrium, which is only maintained by the resistance of the outer layers; so that when this resistance is destroyed by breaking off the thin end or another portion of the drop, the state of equilibrium ceases and bursting takes place.

The experiments whose results I have the honour to present to the Academy seem to prove, on the contrary, that the effects in question are chiefly due to the peculiar condition of the exterior layers, and that the interior play no part, or only a secondary part, in the phenomenon.

The mechanical actions by means of which the drops are ordinarily broken necessarily produce vibrations in the glass, the effect of which it is impossible to appreciate. That is why, in this investigation, I have preferred to make use of fluohydric acid, the action of which can be moderated at pleasure, and which permits us to destroy at will, and without any shock, any portion we wish to attack.

On suspending a Rupert's drop by a thread over a platinum vessel containing fluohydric acid, in such a manner that the extremity of the thin end dips into the liquid, we find that we can always dissolve the whole of the thin end without destroying the drop; but when the acid touches the origin of the neck (that is, the point of divergence of the pair), equilibrium is always broken; the drop then separates into a great number of fragments, and in most instances without explosion.

Reciprocally, the swollen part may be immersed in the acid, the origin of the neck and the whole of the thin end being kept out of the liquid; in this case the drop is completely dissolved without rupture, and the thin end remains intact. If with different drops the experiment is arrested at different stages of the dissolution, it is found that the nucleus which remains presents no longer the properties of the original drop; it no longer breaks up when the thin end is broken off—which shows clearly that the interior mass of the glass does not intervene in the phenomenon.

These two experiments prove at once that the stability of the drop is bound up with the existence of the origin of its neck, since whenever it is preserved no disaggregation of the drop takes place.

Now it is known that chilled glass remains more expanded than if it had been cooled slowly; the exterior layers of the drop, more strongly chilled, are more expanded than the interior layers, which have occupied more time in cooling. We may therefore regard the drop as formed by the superposition of layers of glass unequally chilled and expanded, cemented to one another. The exterior layers, kept by the resistance of the interior ones, can only yield to the force of elasticity which solicits them if, through any cause whatever, they are all at the same time set free to return to their normal state of expansion.

It results, moreover, from the form of the drop, that all these layers, unequally stretched, meet together at the origin of the neck; so that on destroying this the common point of resistance vanishes, and these layers, the actions of elasticity of which are added together, are displaced along the same directions and produce the disaggregation of the system.

If this supposition is correct, one might make a drop burst by cutting it at the large end, in such a manner as to set free at one of their extremities the unequally chilled layers of glass. This is, in fact, what takes place when the large end of the drop is ground off in a lathe, or when we attempt to saw it; the explosion always takes place as soon as a little more than half of the thickness has been attacked.

Another consequence of this hypothesis is, that the vitreous molecules will be displaced in a direction different according to the manner in which rupture takes place. This displacement should be greater for the exterior than for the interior layers, which are less expanded; and it is almost *nil* for the central portions, which have not been chilled at all or but very little. Consequently, on considering the molecules in a plane transverse section of the drop, the eccentric molecules, belonging to the more expanded layers, will be more displaced than those situated nearer to the center, which will be less and less so as they are farther from the surface, so that after the rupture this plane section will have the appearance of a conic surface formed of little needles of glass, arising from the shrinkage on all sides; and the direction of the summits of these sorts of cones will indicate that in which the displacement of the molecules has taken.

If the thin end be broken off, the shrinking will be toward the bulb, and all the summits of the cones will be directed toward the thin end. If the explosion be caused by sawing the big end of the drop, the cones will have their summits directed toward the big end.

That this is what in fact happens I have ascertained by operating in the following manner. I fit some Rupert's drops in plaster, covering only a little more than half of their thickness. The thin end, which is left protruding, I immerse in fluohydric acid. The mo-

ment the neck is attacked the drop is disaggregated, with or without explosion; and the fragments constitute, by their grouping, a series of conic assemblages encased one within another and having their summits toward the thin end. On sawing the big end, the summits have the opposite direction; and if the drop is sawn in the middle, the two opposite arrangements are observed on the two sides of the incision. Operating while the plaster is fresh, we can easily detach the fragments of the drop and establish all the results I have stated.

These facts demonstrate that in the drop the glass is in no peculiar condition other than that which arises from the unequal expansion resulting from the difference of cooling.

Analogous phenomena are presented by thick glass rods which are chilled naturally by cooling in the air at the moment of their fabrication. When these rods (which have always some curvature) are heated at one end, it sometimes happens that they break along their whole length. the fracture being conic and acicular. I am indebted to the kindness of M. Friedel for a fine specimen of this kind. The tubes obtained by letting melted glass flow in threads of more or less thickness into water possess in a high degree the explosive properties of Rupert's drops. They have almost always the form of cork-screws, on account of the extreme expansion of the upper layers; and dipping the extremity in fluohydric acid is sometimes sufficient to cause an instantaneous explosion, with the same characters as in the fracture. In fine, the lumps of glass which remain at the extremities of the canes by means of which the tubes are drawn have the form of large Rupert's drops, and are of considerable weight. When these are detached from the cane they are in the condition of a drop of which the bulb has been sawn; during their cooling in the air they break up, throwing off splinters with violence; and their fracture is identical with that of the small drops broken at the big end. A fragment of one of these large drops, which I had brought from the works of MM. Appert at La Villette, presented an interesting phenomenon: on slightly squeezing it between my finger and thumb, a considerable disengagement of heat was produced; the temperature rose to about 40° C. This confirms the results obtained by M. Dufour concerning the heat disengaged during the explosion of Rupert's drops.

The existence of layers cooled with unequal suddenness in the thickness of the glass affords an explanation of the brittleness of chilled glass. In fact we may suppose that, on account of the low heat-conductivity of glass, a very thin layer at the surface is, from whatever cause, cooled with sufficient suddenness to be in a very different state of expansion from that of the layers beneath. The least shaking, or the slightest change of temperature, will cause it to break; and the fissure will be propagated in the mass of the glass: exactly the same thing takes place when a crack shows itself on pottery the glaze of which has been ill compounded.—*Comptes Rendus de l'Académie des Sciences*, vol. lxxvi, pp. 346–349.—*Phil. Mag.*, June, 1873.

2. *Deep Sea Exploration on board "The Challenger."—Nature* of July 24 and 31 contains No. IV and V of letters from Wyville Thomson. A sounding on the 15th of March of 450 fathoms, off Sombrero, brought up Globigerina mud, with broken shells principally those of pteropods. In other soundings between this and 1,000 fathoms similar results were obtained. Several sponges of the Hexactinellidæ were procured, closely allied to those in moderately deep water off the coast of Portugal; among stoney corals, a *Stylaster* near *S. complanatus* of Pourtales; crustaceans referred to the Astacus family, totally destitute of eyes, one named *Astacus zeleucus* nearly 5 inches long. Leaving St. Thomas on the 24th of March toward the Culebra passage, and sounding the next morning in 625 fathoms, the ooze brought up was like that before obtained, but closer and more free from shells. They secured also the little Crinoid, *Rhizocrinus Lofotensis* and the sea-urchin *Salenia varispina*, besides many corals, the most of which were species described by Pourtales, and the sponge *Hyalonema toxeris* (new) resembling the *H. Lusitanicum* and *H. Sieboldi* in general appearance and the arrangement of its parts.

March 26, nearly 90 miles south of St. Thomas, in lat. 19° 41′ N., long. 65° 7′ W., they sounded again in 3,875 fathoms. The bottom brought up in the tube was reddish, the upper layer of it the most so. The dredge was also used; it brought up a gray ooze mottled with red; the whiter portion effervescing freely with acid, the rest but little. No animals were found in the mud excepting a few small foraminifers of both the calcareous and arenaceous kinds, showing the paucity of life at extreme depths. The next day, the 27th, they sounded in 2,800 fathoms, on the 28th in 2,960, and on the 29th in 2,850 fathoms, with the same results as to paucity of life, but in the last bringing up only the red clay, the calcareous element being nearly wanting. This red clay extends for 1,900 miles between the Canaries and the West Indies.

April 4th, the expedition reached the Bermudas.

3. *Petroleum of Upper Burmah.*—This mineral oil is found at Yeynangyoung and Pagan. There are at present about one hundred and fifty wells worked at Yeynangyoung; the quantity of oil estimated as deliverable from these wells is 15,000 viss daily, of which 10,000 viss is taken by the contractor who supplies British Burmah, and 5,000 viss by the contractor who supplies Upper Burmah. The total yield of these wells is 6,000,000 viss per annum, or 9,375 tons. There are many abandoned wells, and wells that produce very small quantities of oil. At Pagan there are about fifty wells: they yield daily 1,500 viss of oil, which the earth-oil contractors, at present the Lay-myo-woon and one Moung Tsanwah, are allowed to purchase. The oil from these wells is obtained in a more liquid state and more resembles naphtha. It is of a brackish nature, and is better suited for lighting purposes than the Yeynangyoung oil. The total supply of earth-oil in Upper Burmah now per annum is 6,600,000 viss or 10,312½ tons.—*G. A. Strover, Rep. to Gov. of India, Dept. of Agriculture Revenue and Commerce*, January 22, 1873.

4. *India-rubber or Caoutchouc of Upper Burmah.*—The estimated number of trees, which are chiefly situated in the Bhamo and Mogoung districts, is 400,000. They thrive best in damp, moist soil, and in thick forests, shady and cool. The trees attain to a height of from 50 to 100 cubits, being from 15 to 20 cubits in girth at the base (full-grown trees) and with roots creeping over the ground for some distance. They are fit for tapping when from 6 to 10 years of age, at which time they are from 15 to 20 cubits in height and 3 cubits in girth.

When the time for tapping arrives, incisions are made in the trunks of the trees and in the roots above ground. Hollow bamboo cups, about 1½ foot in length, sloped and pointed similar to a prepared pen, are then inserted in the incisions and receive the oozing juice or milk. Three or four hundred of these bamboo receptacles are inserted in each tree. The tapping is continued for about a month, after which time it is discontinued and the wounds allowed to heal. At the expiration of another month the trees have regained strength, and tapping is re-commenced.

In preparing the India-rubber the following crude method is observed.

Water is boiled in large iron pans, and the juice of the tree is thrown in, when it gradually thickens, and subsequently is dried. The India-rubber so obtained is being brought into local use for covering water-buckets, baskets and boxes as a substitute for dammer.

The existence of the India-rubber tree in Upper Burmah does not appear to have been known, or, at any rate, it did not attract attention, until somewhat recently, when three Europeans, Messrs. Miller, Marshall and Henri, who were employed at the jade stone mines, were forced to look and search about in the forests for a substance that would effectually repair a diving apparatus that they used in working for jade stone. They found India-rubber and repaired the apparatus. The existence and value of the juice was then brought to the notice of the King, and Mr. Henri is now employed in tapping the trees and preparing the juice. Some 70,000 viss of India-rubber was brought from Mogoung last year. I myself saw 30 or 40 cart-loads of it entering the palace one day. Upper Burmah could produce 2 or 300 tons of this useful substance per annum.—*Ibid.*

5. *The Lalande Medal to Prof. Watson, August 1st.*—Prof. James C. Watson, of the University of Michigan, who has charge of the Observatory at Ann Arbor, has received a gold medal awarded him by the Institute of France for valuable astronomical discoveries. The Ann Arbor *Register* gives a description of it, and says: "The medal was awarded to Prof. Watson by the Institute of France, in July, 1870, but on account of the war its completion and transmission were delayed. It was made at the French Mint, and accompanying it was the certificate of the Director of the Mint as to its fineness and weight, as well as 225 francs in bills of the Bank of France, being the unexpended

balance of the sum appropriated by the Institute for the medal. It is exquisitely wrought and has on one side a bust of Minerva in half relief, surrounded by the words: 'Institut Imperial de France, Constit. Art. lxxxviii.' The other side has inclosed in a massive wreath the following words: 'Académie des Sciences, Prix d'Astronomie, fondation Lalande, James Craig Watson, 1869.'"

6. *Meteoric iron.*—The mass of meteoric iron which was found at Neuntmannsdorf, in Saxony, in December last, weighing twenty-five pounds, has been bought by the Museum at Dresden.

7. *Pre-Historic Races of the United States of America;* by J. W. FOSTER, LL.D. 8vo, pp. 415. Chicago, 1873: D. C. Griggs & Co.; London: Trübner & Co.—This interesting volume reached us in the same week which brought the sad tidings of the death of the author, already announced on page 160 of this volume. It is no doubt much the most important of Col. Foster's works. The subject had long engaged his attention, and his own researches have added important facts and conclusions respecting this department of ethnology. The subject is treated in twelve chapters: I. Antiquity of Man—Evidences in Europe. II. The same—Evidences in the United States. III. The Mound Builders—The Geographical distribution of their works. IV. Shell-banks—Their Geographical distribution. V. Mounds and Enclosures. VI. The Mound Builders—Their Arts and Manufactures. VII. Ancient Mining by the Mound Builders. VIII. Crania of the Mound Builders. IX. Manners and Customs as the basis of Ethnic relations. X. Who were the Mound Builders? XI. The Unity of the Human Race. XII. Chronometric measurements as applied to the Antiquity of Man. There are 72 illustrations on wood, largely drawn from materials now for the first time brought together. The style of the text is animated and generally in good taste. Ample references to contemporary literature are given, and while the volume is avowedly only a compendium, it is not a mere compilation, but bears the marks of the hand of an original observer. The mechanical execution of the work does credit to new Chicago. Had the author lived to revise his work for a second edition, he would undoubtedly have eliminated some errors of the press and some slips of the pen, which the careful reader will note in perusing the volume.

9. *Mittheilungen der deutschen Gesellschaft für Natur und Völkeskunde Ostasiens.*—Herausgegeben von dem Vorstande. 1st Heft. 26 pp. Small fol. May, 1873. Yokohamā, Japan.—This publication is the first number of the Transactions of a scientific Society in Japan—a Deutsche Gesellschaft. The number contains meteorological observations, observations on a large cephalopod of the genus *Ommastrephes* found in the Japan seas, and various historical papers. The length of the Ommastrephes, from the point at the hinder extremity, to the front edge of the mantle was 186 centimeters (6 feet 1 inch), and 41 cm. (1 foot 5 inches) more

to the mouth. The longer of the eight arms measured 197 centimeters or nearly 6½ feet.

10. *Bulletin of the Buffalo Society of Natural Sciences*, Vol. I, No. 2, 1873.—The contents of this second number of the Bulletin, are, Descriptions of new species of Fungi by C. H. Peck, (occupying 32 pages); Contributions to a Knowledge of N. A. Moths, by A. R. Grote; A study of N. A. Noctuidæ, by A. R. Grote. The number contains two excellent lithographic plates containing figures of Moths.

The President of this Society is GEORGE W. CLINTON, LL.D.; the Vice-Presidents, H. CHANDLER, G. E. HAYES, and S. S. ROGERS; the Corresponding Secretary, L. F. HARVEY, M.D.

11. *Academy of Sciences of France.*—Of the elections mentioned on page 159, the first was in place of Prof. Agassiz, who had been advanced from the list of Foreign Correspondents to that of Foreign Associates; the second, in place of M. Pictet of Geneva, deceased, and the third in place of M. Pouchet, deceased.

12. *German Association of Naturalists and Physicists.*—The 46th meeting of this association will be held this year at Wiesbaden during the week commencing September 18th.

13. *British Association for the Advancement of Science.*—Dr. JOULE, of Manchester, the president-elect of the year, being unable to be present at the coming meeting of the Association, owing to the state of his health, Dr. A. W. Williamson of University College will probably be chosen to the office of President.

14. *The French Association for the Advancement of Science.*—The annual session was appointed to be held at Lyons, during the week commencing August 21.

OBITUARY.

GUSTAV ROSE.*—This distinguished mineralogist died at Berlin, July 15, in the 76th year of his age. In him Germany and the world have lost a wise and noble man,—conceded by all to be the first in his science among the learned men of Germany. He was the younger brother of Heinrich Rose, the chemist, and the youngest of four sons of Valentin Rose, who was Assessor in the "Ober-Collegium Medicum" of Berlin; and grandson of Valentin Rose the elder, discoverer of the "Rose'schen" metals. He early lost his father, and his excellent mother looked after the culture of four sons, whose youth fell upon hard and trying times. All four brothers served their country in the war for freedom. Gustav, born on the 18th of March, 1798, and 17 years old at the date of the battle of Waterloo, did not go into that battle, but made the march under arms from Berlin to Orleans.

At first devoting himself to engineering, he fell sick of lung fever. During his convalescence he gave himself to scientific pursuits, and this, as well as the influence of his brother Heinrich, led him to leave engineering and devote himself entirely to science. He went to Stockholm where Heinrich was already working under

* From the German of Prof. vom Rath, of Bonn.

the immortal Berzelius. In 1823 he took up his residence in Berlin. In 1826, he became "Extraordinary," and in 1839, "Ordinary" Professor of Mineralogy in the University of Berlin, and, after the death of Weiss, Director of the Royal Mineralogical Museum.

It was the privilege of Gustav Rose to travel extensively, in Scandinavia, England and Scotland, Italy and Sicily, France and Austria. In the year 1829, he made, with Humboldt and Ehrenberg, the famous tour to the Ural and Altai Mountains and the Caspian Sea, and beyond to the borders of China, a journey which first made known the mineralogical resources of the extensive Russian Empire. His researches on his native soil were confined to the Silesian Mountains.

G. Rose was the first in Germany to use the reflecting goniometer in accurate measurements of the angles of crystals. He took an active part in the researches which led Mitscherlich to the important discovery of isomorphism. His work covered all departments of mineralogy, the form and combinations of crystals, physics in its applications to crystallized substances, the chemical constitution of minerals, and their artificial formation. He was the great master in the art of crystallographic drawing. The science of the association of minerals in rocks, petrography, originated with him. He was also the first to teach us the method of studying rocks by means of thin microscopic sections mounted on glass slides, in which minerals invisible to the unaided eye are disclosed.

With a special predilection he devoted himself to the study of meteorites, those wonderful bodies which reach the earth from the depths of space. With his keen penetration he discovered the structure of the iron meteorites and the mineral components of stony meteorites, and studied out the striking differences between rock-making in a cosmic atom, and in the solid crust of the earth.

It is worthy of remark that his best mineralogical discoveries were made not always on rare bodies, but often on those which had been long familiar and were common in collections. An example of this is his recognition of right and left-handed quartz crystals by their exterior forms; the complex twin crystals of the same species, etc. The secret of his success was that he did not observe simply form, but all the physical characters of the species; when searching into nature's work, his mind grasped whatever in the wide range of facts could serve as a key to the solution of the difficult problem before him. During his later years his researches were devoted to the "king of stones," the diamond. Few mineralogists would have thought that the diamond yet offered unsolved problems. In his anxiety that his work should not be lost to science, only twenty-four hours before his death he dictated to his son the results of his latest researches. Perhaps the final solution of the problem of the crystallization of the diamond was not attained by him; but he was near reaching his aim. His life, in thought and action, reflected Bacon's maxim "Pertransibunt multi, sed augebitur scientia." He was

a true student of nature, an eminent and effective worker for the progress of science and the exposition of the system of nature.

We can scarcely find a better example than in Gustav Rose of the joy from a growing knowledge of nature lasting to the evening of life. Looking back over his long life, he saw how many dark paths of science had been followed out and made clear. This filled him with delight and high hope. "You will yet have more light," he said to the young. "Much must perish, but science will continue to increase." He saw his co-workers and best friends, Mitscherlich, Magnus, Haidinger, above all, his brother Heinrich, called from their work. Their departure and his increasing loneliness filled him with pain. Still he rejoiced in the thought of how much science had been advanced by the common efforts of his departed friends. Thus his spirit exhibited the uncommon spectacle of augmenting cheerfulness to life's close. Three years since it was decided to celebrate his "Doktor-Jubiläum," on the occasion of his completing a half century as an instructor. He never sought honors, but nevertheless all honors fell to his share. When he was made Knight of the Order *pour la mérite*, he considered the distinction too great for him.

Imperishable is the memory which Gustav Rose has left. Not only imperishable, but a memory that is living and active in the hearts of all who knew him. In his science and his many-sided relations to life, he had no enemy, no opponent, no envy, no evil-wisher to disturb him. He lived in a profound peace, of which his eyes were the speaking witness, whose peculiar soul-full outlook astonished all with whom he spoke. What is often so hard to the best men, to live in peace and friendship, was allowed to him. As he always strove to judge from a sense of the good, the true and the beautiful, so he expected the same judgment from others. He recognized in the efforts of others only the good. If words and deeds did not accord with his views, he did not attribute to others evil motives—and thus he won to himself the love and respect of all who came in contact with him.

Gustav Rose, in his life, as well as in his science, has left us an example hard to imitate. Until the 11th of July he still gave his lectures. Notwithstanding his great debility,—feeling, he says, "as if I had climbed the "Hummerich" and the "Löwenburg,"—he wrote in the evening a long scientific letter, closing with the words "Rest will do us good; we will go again to our old quarters in Friedrichshafen; would we were there now!" Scarcely had he closed the letter when he was seized with a chill, the premonitory symptom of pneumonia, which, in less then four days, ended the life of the best of men.

Now rests from its work the hand which wielded the hammer with strength, and with exquisite delicacy drew the finest lines of crystal figures; and from their work rest the eyes which saw the snowy summits of the Altai, and distinguished the "matt" and the "glänzend" on the surfaces of rock-crystals. Peace to his ashes! Blessed are the peacemakers!

Bonn, July 16th, 1873.